SCIENCE ABSTRACTS.

Section A.—PHYSICS.

FEBRUARY 1920.

GENERAL PHYSICS.

181. *Simple Theory of Knudsen Vacuum Gauge.* **G. W. Todd.** (Phil. Mag. 38. pp. 381–382, Sept., 1919.)—Knudsen's expression for the gas pressure in terms of the scale deflection, temperatures, and constants of the instrument is very simply derived by Joule's device of dividing the gas molecules into six streams in the space between 2 parallel strips at a distance apart less than the mean free path of the gas molecules, and the assumption of a complete energy exchange in the collisions between the molecules and the strips. G. W. de T.

182. *Strain Measurements of Plates pierced with Circular Holes.* **E. G. Coker, K. C. Chakko, and Y. Satake.** (Inst. Eng. and Shipbuilders, Trans. 63. pp. 33–76; Disc., 77–86, Dec., 1919. Engineering, 109. pp. 259–264, Feb. 20, 1920.)—Describes an investigation of the effect of a circular hole (such as a rivet hole) on the stress distribution in plates of different sizes. The stress distribution produced by a central hole in a plate of infinite width is capable of mathematical solution and is reproduced in an appendix to the paper. The present work consists in the optical determination of the strain distribution about a hole in a transparent sheet of nitro-cellulose. It is found that, on the whole, the agreement between the results obtained by this method and the effects actually observed in perforated steel is sufficiently close to warrant experiments on optical materials being accepted as applicable to engineering materials. Whatever the size of the hole, the intensity of the stress at the inner edge is three times the average stress.

In the *discussion,* **A. McCance** said that if this distribution of stress around a hole were assumed to remain the same for the microscopic holes caused by small particles of non-metallic matter in steel, the results obtained would give a possible explanation of certain cases of failure. For if one particle happened to lie within the area of disturbance caused by a neighbour, their stress effects would be superimposed and the resulting stress might reach a very high value. J. W. T. W.

183. *Notched Bar Tests.* **W. C. Unwin.** (Engineering, 108. pp. 329–330, Sept. 12, 1919.)—In comparing the results of notched bar tests made on the same material but with bars of different dimensions it is

suggested that W/a^n is a constant, where W is the work of rupture in kg.-m. and a is the area in cm.². The value of n will depend on the material, being greater for very tough material such as copper than for steel. The following table shows what sort of agreement the use of this formula entails.

Material.	Work of Rupture.		n.	W/a^n.	
	30 × 30 mm.	10 × 10 mm.		30 × 30 mm.	10 × 10 mm.
Steel A........	108	8·21	1.17	18·6	18·5
Steel J	81	6·24	1·17	13·9	14·0
Steel P	45	2·38	1·34	6·0	6·0
Copper	55	2·47	1·41	6·6	6·6

F. C. T.

184. *Investigation of Metals with regard to their Internal Friction.* **M. Ishimoto.** (Phys. Math. Soc. Japan, Proc. 1. pp. 267–276, Oct., 1919.)—For a vibrating torsional pendulum $\theta = Ae^{-bt/2I} . \cos (pt + \delta)$, where θ is the angle of twist, I the moment of inertia of a body attached, a a coefficient related to the rigidity and a function of the temperature, and b a factor (also dependent on temperature) which decides the rate of damping, $p = (a/I - b^2/4I^2)^{1/2}$. In the experiments the time T was measured in which torsional vibrations induced magnetically fell to a constant fraction of the initial values. For pure iron and in carbon steels this time falls to a minimum at about 65° C., then rises again to a maximum from 140° to 230° C., according to the carbon content, after which it falls away, becoming at 500° C very low. For nickel a well-marked maximum occurs at 250° C. Curves are also given for copper and aluminium. The Brinell hardness of a 0·2 % carbon steel shows a minimum of 81 at 105° C. and a maximum of 104 at 290° C. F. C. T.

185. *Vibrations of Cylinder in Fluid Flow.* **H. Nagaoka.** (Phys. Math. Soc. Japan, Proc. 1. pp. 277–283, Oct., 1919.)—It is well known that the flow of a fluid past an obstacle sets up vibrations in the latter in a direction perpendicular to that of the flow, owing to the formation of vortices. The solution for the simple case of an infinite cylinder with its axis perpendicular to the direction of flow of an incompressible fluid gives rise to columnar vortices, causing circulation about the axis. If a be the radius of the cylinder, ρ the density of the fluid, u, v, the velocity components, κ the circulation about the axis, x the direction of motion, then the components of force acting on the cylinder are $X = \pi a^2 \rho \dot{u}$, $Y = - \kappa\rho u + a\rho\dot{\kappa}$. For a steady current, $\dot{u} = 0$, so that the vibrations will be wholly transverse, but for cases such as a chimney in an air current or a cylindrical bridge pier in a water current, $\dot{u}$ will not in general vanish. The author therefore assumes that $u = u_0 + \Sigma A_n \cos (p_n t + \alpha_n)$, $\kappa = \kappa_0 + \Sigma B_n \cos (q_n t + \beta_n)$, and discusses the forced vibrations of the chimney or column on the assumption that those not in resonance with the period proper to either may be disregarded as ineffective. The analysis shows that a train of beats is to be expected in the transverse vibration and states that they have been observed in the case of a tall

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chimney. When the velocity of the wind is variable with the height the variation of u and $\dot{u}$ will have to be taken into account in calculating the bending moment, the variation near the end being the most effective; and here also the error in the formulæ, which do not take account of the end effect, will be greatest. G. W. DE T.

186. *Measurement of Flow of a Liquid.* **C. Camichel.** (Rev. Gén. d'Él. 6. pp. 707–709, Nov. 22, 1919. Am. Soc. Mech. Eng., J. 42. pp. 56–57, Jan., 1920.)—This paper describes a method of measuring the velocity of liquid flow in its passage between glass plates by photographing the liquid charged with small particles in suspension. The apparatus is viewed in transmitted light, and the beam of light is interrupted uniformly by means of a rotating toothed wheel. From the photographs taken the displacement of the particles can be measured. As examples, the paper gives the study with photographs of vertical flow between two parallel plates, and of a vortex with its axis vertical. W. A. R.

187. *Mechanical Damping of Oscillating Systems.* **O. Martienssen.** (Zeits. Instrumentenk. 39. pp. 265–273, Sept., 1919.)—Describes in detail the different methods adopted for damping oscillations. Most of these employ fluid friction as the damping agent, and a treatment is given of the theory of the method and the decrement obtained under given conditions. J. W. T. W.

188. *Absolute Determination of the Coefficients of Viscosity of Hydrogen, Nitrogen, and Oxygen.* **Kia-Lok Yen.** (Phil. Mag. 38. pp. 582–596, Nov., 1919.)—Practically all the most careful measurements of the viscosity of gases have hitherto been made by the transpiration method. Since, however, it is an impossibility to obtain capillaries of uniform bore and next to impossible accurately to determine the size and shape of the bore when it is not uniform, and since there is always a possibility of the formation of eddies at the ends of the capillaries and a consequent distortion in the lines of flow of the transpiring gas, the transpiration method is neither mathematically rigorous nor experimentally exact, and so even the most careful and accurate determination is but relative. Consequently Millikan and his students, in America, have developed a constant-deflection apparatus, the behaviour of which has proved most consistent and the results of which can lay claim to accuracy of a much higher degree than has ever been achieved by any other method. The method has already been described [see Abs. 187 (1917)] and consists in causing one cylinder to revolve with a constant angular velocity about another which is suspended by a torsion thread, and measuring the angle through which the inner cylinder is displaced from its position of rest. The measurements were carried out by the author at 23·00° C. and under a pressure of 76 cm. of mercury, and the results obtained for the various gases were as follows, the values of the viscosity given being in terms of $\eta \times 10^7$: Hydrogen, 882·16; oxygen, 2042·35; nitrogen, 1764·80; the probable error of each value is 0·15 %. Details are given of the methods of preparing and purifying the gases used. The method is very sensitive to the presence of impurities in the gas. For example, the addition of 5 %, by volume, of nitrogen to hydrogen caused the viscosity to change from 882×10^{-7} to 1092×10^{-7}, that is, a change of almost 25 %. T. S. P.

189. *Projective Time Scale, Space Scale, and Kinematics.* **L. Silberstein.** (Phil. Mag. 38. pp. 382-394, Sept., 1919.)—The usual, and only known, chronometrical procedure involves the dissection of the history of a moving particle, or of a light flash, by an extraneous process which implies the concept of rigid bodies. But the author shows that what he terms a projective time scale can be set up without the aid of any space scale of points. He takes for granted such concepts as *instant of time*, *distinct* instants, *earlier and later* (at a spot at least), and *between* two instants; and, as in ordinary chronometry, the *uniform motion* as principal undefined term, rendering it more explicit by the statement that certain undefined motions of a particle along a straight path shall be called uniform motions. These are subsequently defined, in part at least, by assumptions enunciated about them. Space is taken as the ordinary three-dimensional projective space, *i.e.* independent of any idea of measurement, only two of its dimensions, a projective plane, being required. The space-time, necessary to prove the determinations of the scale, will therefore form a *three-dimensional world*, and the subject of the experiment (actual or mental) giving the scale will be a single, one-dimensional space line.

Call the passage of a particle p through a point A of the plane at a time instant a the event, or world-point, a; and the succession of such, a history or world-line of p. Let p be capable of moving along any fixed straight in the plane. Impose the further condition that, A and B being points on the line, p shall pass through them at a and b, and, say, b later than a: there will still be an infinity of world-lines joining the world-points $\alpha =$ A, a and $\beta =$ B, b. Assume then, further, that between any two world-points there is only one uniform or *right* world-line, the correlate to the primary axiom of ordinary projective geometry. Consequently, two right world-lines do not intersect more than once. Similarly assume the remaining correlates, the axioms of order and connection. All these assumptions apply to any straight path, a two-dimensional manifold (X, t), say, in the selected plane (X, Y, t), say, having all the properties of a projective three-dimensional space. Now, the Desargues theorem applies to the latter without requiring the congruence axioms, and therefore also to (X, t), so that any three collinear world-points therein will uniquely determine a fourth point; and reciprocally, any three concurrent right world-lines will uniquely determine a fourth line. The time scale can now be constructed, in mental experiment with particles p moving along the same X-straight, graphically by drawing the corresponding straights in the plane (X, t). Let $t = 0$, 1, T be three conventionally fixed instants in order of lateness represented by straights through an arbitrary centre Ω_x. Through any point in $t = 0$ draw straights p_1, p_2 crossing $t = 1$ in α, β, and $t =$ T in γ, δ. Draw p_3, joining α, δ, and p_4 joining β, γ, and crossing p_3 at ϵ. The line $\Omega_x\epsilon$ will then represent the X-straight at a definite instant. Call it $t = 2$. The straight joining the crossing of $t = 2$, p_1 with δ will cross p_4 at a definite instant $t = 3$, and so on. Here we may introduce the generalised archimedian postulate, *i.e.* assume that every instant of time between 0 and T, and distinct from T, can be exceeded by a finite repetition of this process. The index to be given to the instant T itself will evidently be $\pm_{\infty}$ according to the direction of approach, so that T will be a singular point on the time scale, as on the corresponding and similar space scale. The latter can be obtained by reasoning as before, but replacing the

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pencil Ω_x of world-lines of constant date, by a pencil Ω_t representing particles fixed at $x = 0, 1$, S. Having thus obtained a scale of instants and points along a straight (p_4), projective coordinates x, t may be set up, defining an event in the world x, t, in much the same way as in ordinary projective geometry, the supplementary continuity axioms being properly introduced. Velocity and acceleration may then be defined, if $x = f(t)$ be a single-valued function, by the equations $\dot{x} = f'(t)$, $x = f''(t)$; so that the material for a system of *general* or *projective kinematics* can be put together without the aid of clocks or rigid measuring rods.

The assumption that two uniformly moving particles do not meet more than once leaves three possibilities—that the $x \cdot t$ world might be elliptic, parabolic, or hyperbolic. If elliptic, not merely would time be cyclic, which is logically possible, but two fixed particles would have to be considered as meeting, which would greatly strain our language and ideas, so the author rejects this solution. If parabolic, then, p and q representing particles moving uniformly along the x-line, the axiom would take the form:—Through a world-point a, not on p, there is one and only one world-line q not intersecting p. Or if p be assumed fixed at a point A (no real loss of generality), the only particle q which, being at a certain instant at B, distinct from A, neither met or will meet p, is that which remains at B. Every particle which moves uniformly towards or away from A, no matter how slowly, will reach A or has passed through A. This seems almost a truism, but as in the case of Euclid's parallel postulate, to which it corresponds, it is not a consequence of the projective axioms. If hyperbolic, the axiom would take the form:—Let an infinity of particles q be at B at instant b. Some will be or have been at A, others, including q_0 which is fixed at B, neither will be nor have been. The class of the latter is divided from those of the former which approach A by a limiting particle q', and similarly, from those which recede from A by a particle q'', and q', q'' have distinct histories. In other words, through the world-point $\beta = (\text{B}, b)$ there is a whole pencil of right world-lines not intersecting p, and divided from the intersecting ones by two distinct world-lines q' and q'', the world analogue of Lobachevsky's parallels. If q', q'' coincide, the hyperbolic world reduces to the parabolic. The paper concludes with a brief comparison of projective with metrical kinematics, parabolic and hyperbolic.

G. W. DE T.

190. *Time Measurement.* **N. Campbell.** (Phil. Mag. 38. pp. 652–654, Nov., 1919.)—The author objects to Silberstein's "mental experiments" [see preceding Abs.], and states that a standard time-scale can be derived from these definitions: (1) The period of a definite process in a definite system = 1; (2) the periods of two events are equal if, when matters are so arranged that the beginnings are simultaneous, the ends are simultaneous; (3) a period C is the sum of two other periods A and B if, when the beginning of A is simultaneous with the beginning of C, and the end of A with the beginning of B, then the end of B is simultaneous with the end of C. The period need not involve uniform motions, for it might be the time of fall of a body from one position to another. It need not even be that of a moving system and need not therefore involve space. A system of intervals represented by integral numbers may then be built up by the aid of a pendulum, and fractions obtained by other pendulums, and the principles and experimental proof are of precisely the same nature as those involved in the building up, by means of a balance, of a scale of weights on the basis of the three definitions: (1) The weight of a certain body = 1; (2) weight of P = weight of Q if P and Q balance when placed in the pans of a balance of specified construction; (3) C has a weight equal to the sum of A and B if A and B together balance C. G. W. de T.

191. *Mass carried forward by a Vortex.* **W. M. Hicks.** (Phil. Mag. 38. pp. 597–612, Nov., 1919.)—When a vortex aggregate moves steadily through an irrotational liquid, three definite regions of fluid motion are in general distinguishable: (1) The ring or aggregate itself, which is in rotational motion and retains its identity and constituents independently of energy changes, the portion in irrotational cylic motion surrounding (1), which retains its identity and volume so long as the energy is constant and travels uniformly through the liquid like a solid, (3) the irrotational acyclic motion outside (2), all displacements in which are small throughout and zero at infinity. The author points out that comparatively little attention has been devoted to the relations between the regions (2) and (3) which form the subject of the paper. When the aggregate moves uniformly with velocity U relative to the fluid at a great distance, the ring may be supposed to become stationary by imposing everywhere a velocity − U. The boundaries between the three regions will then appear fixed. The boundary between (1) and (2) is always a ring surface, even when the aperture closes up. Between (2) and (3) it may be a ring surface, or may appear to an observer travelling with the ring as a simply connected surface, past which the outer liquid streams. Thus the boundary, mass and energy of the portion translated through the liquid, and the energy of the region (3) can be determined. The mathematical development of a general theory is followed by a more detailed discussion of the two special cases of two parallel straight vortices and of a single ring vortex of uniform vorticity. G. W. de T.

192. *Nature of the Forces between Atoms in Solids.* **R. W. G. Wyckoff.** (Washington Acad. Sci., J. 9. pp. 565–592, Nov. 19, 1919.)—The structure of the atom is discussed with reference to the nature of the forces operating between atoms, and it is emphasised that only the arrangement of the outside electrons has a bearing on the phenomena usually included under the term "chemistry." The arrangement of the inner electrons cannot be deduced from chemical data alone. The outstanding fact is the tendency, still unexplained, to form "closed clusters" of eight or twice-eight electrons.

Several typical compounds are considered with reference to the nature of the forces producing them. All compounds lie between the two extremes of "polar" and "non-polar" compounds. A simplified method of representing the type of combination in a finer compound is suggested. Solid substances are classified, according to the nature of the forces of combination, into molecule-forming, polar, and valency compounds.

The phenomena of adsorption, solubility, ionisation in solution, formation of complex ions, and molecular complexes, are discussed from this point of view. A. B. W.

193. *Equilibrium and Stability Studies of the Positive Nucleus of Haas.* **H. Schmidt.** (Dissertation, Leipzig, 1919. Phys. Zeits. 20. pp. 446–450, Oct. 1, 1919. Preliminary communication.)—The equilibrium grouping of electrons in plane polygons had been investigated by J. J. Thomson in 1904. A. Haas [Abs. 1229 (1917)] further studied the possible equilibrium arrangements of the electrons in polyhedra, rectangular prisms, and simple and double pyramids. Continuing the investigation of Haas and accepting his positive nucleus, the author finds that the number of possible equilibrium positions is very great. The smaller the nucleus charge, the more open the structure will become; the several rings of electrons approach one another, but recede from the centre, and the prisms and pyramidal bases expand, both when an electron is added or when the system is deformed by rotation. When, however, the stability criterion of Lejeune-Dirichlet is applied, the number of possible equilibrium positions is very much reduced, and it would appear that stability is only possible when the rings of different numbers of electrons are arranged in parallel planes, symetrically to the axis passing through the centre of the nucleus.

The problems of the electric forces are further to be studied for large numbers of electrons. H. B.

194. *The Atomistic Constitution of a Crystal Surface.* **E. Madelung.** (Phys. Zeits. 20. pp. 494–496, Nov. 1, 1919.)—Although the atoms in the interior of a crystal are arranged with a regularity corresponding to the crystal system, certain deviations are to be expected at the surface, since the outermost atoms do not possess neighbours on all sides like the inner atoms. The present paper shows that, on symmetrical grounds, for the case of regular crystals of the NaCl type, displacements may only take place perpendicular to the surface opposite to the normal arrangement. The calculation is made in a schematic way in which only forces between the nearest neighbours are assumed. This hypothesis has been used in previous calculations [see Abs. 1173 (1912)], and has rendered a qualitatively correct representation in all cases. The displacements are also regarded as small, so that only linear relationships occur. Finally, the forces between the atoms are assumed to depend only on their nature and distance apart, *i.e.* central forces. The author then establishes that in the surface of a regular diatomic crystal the atoms of one kind are displaced perpendicular to the surface with respect to those of the other kind. This displacement falls off towards the interior as a pure exponential function. Relationships may exist so that on the one hand the displacements exactly disappear, while on the other hand these may be so great that the physical behaviour may be influenced; *e.g.* crystal form, vapour pressure, solubility, etc. The atoms of electrolytes (salts) carry electrical charges, so that an electrical double layer must occur in the crystal surface in consequence of these displacements.

The author concludes that the kinetic theory of the Eötvös law only leads to correct results on the assumption that the molecules of liquids are arranged within small zones in space-lattices. H. H. Ho.

195. *Further Measurements on the Rate of Ascent of Pilot Balloons.* **C. J. P. Cave** and **J. S. Dines.** (Roy. Meteorolog. Soc., Quarterly J. 45. pp. 277–282; Disc., 282–283, Oct., 1919.)—Measurements of the rate of ascent of pilot balloons were made in the Albert Hall through a vertical distance of 40 m. A formula which had previously been developed was: rising velocity $V = q \, . \, L^{1/2}/(W + L)^{1/3}$ where L = free lift and W = weight

of the balloon. The value of q was tested under different conditions. The large fluctuations in rising rate between one ascent and another made the work difficult. These differences are ascribed to the instability of the wake of a moving sphere. It was found that when a cone was attached to form a rough streamline tail to the sphere the resistance was reduced though the fluctuations remained. The fact that a load hung below the balloon may increase its rate of ascent, previously established, was further investigated. Comparative ascents made with and without a length of cotton attached to the balloon showed that some decrease in the rate of rising was produced by the cotton. A lantern hung below the balloon, as used for night ascents, produced no sensible effect on q. There was some indication that q is not an absolute constant, but varies to some extent with the size of the balloon. In the *discussion*, **E. Gold** suggested that measurements might be made in the free air by observing balloons from the platforms of the Eiffel tower or similar structure. **N. Shaw** thought that some steadying device should be introduced to ensure that the balloon would go up in a straight line through the air. J. S. Di.

196. *On the Use of the Normal Curve of Errors in Classifying Observations in Meteorology.* **E. H. Chapman.** (Meteorolog. Office, Professional Notes No. 5. pp. 52–60, 1919.)—A classification of weekly meteorological mean values to show whether the values are exceptionally large or small in comparison with what is usual, is carried out in the *Weekly Weather Report* by making use of the frequency of occurrences of the values on the average out of 12 possible occasions. Thus, in the case of weekly mean values of temperature for a district it is said that temperature is very unusually high or low if the value occurs only once or less in 12 occasions; it is unusually high or low if it occurs more than once, but not more than 3 times out of 12, and it is moderate if it occurs at least 4 times out of 12.

The author suggests as an alternative method of classification the stages determined by the following limits: $m \pm 3\gamma$, $m \pm 2\sigma$, and $m \pm \sigma$. Here m is the mean, and γ the standard deviation of the values, the distribution of which is supposed to follow the normal curve of errors. The stages determined by the limits would be designated by expressions, such as exceptional, very unusual, unusual, and not unusual. Exceptional values would occur not oftener than 1 out of 750 times, very unusual values not oftener than 1 out of 50 times, unusual values not oftener than one out of six times. Not unusual values would then occur at least 2 out of 3 times. R. C.

197. *Polarisation of the Night Sky.* **R. J. Strutt. [Rayleigh.]** (Astrophys. J. 50. pp. 227–228, Oct., 1919.)—It is of interest to determine whether the faint light which appears in the background of the sky at night is polarised. In this way we may hope to determine whether or not the light is scattered sunlight. A Savart polariscope was arranged for photography in a manner which is briefly described. Night exposures were made at Terling, Essex, on two clear nights with the moon below the horizon and the aperture pointing to the Pole star. The Savart bands could be seen without doubt. It is inferred that the night sky shows some polarisation, but much less than the day sky. J. S. Di.

198. *Note on Polarisation of the Night Sky.* **H. D. Babcock.** (Mt. Wilson Solar Observat., Contrib. No. 171. Astrophys. J. 50. pp. 228–231, Oct., 1919.)—The apparatus used was constructed on lines suggested by Anderson; it proved an exceedingly delicate detector of polarised light, and is here described in some detail. Exposures were made at Mount Wilson towards the northern sky at midnight in a direction about 90° from the sun. All were taken within a day or two of new moon. Eight photographs suitable for discussion were obtained. Evidence of very slight polarisation was found upon two or three of them. It is considered that probably not more than 1 % of polarisation existed in the light from the background of the night sky. J. S. Di.

199. *Isostasy.* **J. Barrell.** (Am. J. Sci. 48. pp. 291–338, Oct., 1919.)—Isostasy embraces the theory of the relationships between the relative surface relief of segments of the earth's crust and the densities of those segments. In the case of high relief the mass above sea-level is balanced by a deficiency of mass below sea-level, and that deficiency is called the *isostatic compensation.* The *depth of compensation* is the level where the difference in densities will have completely neutralised, for perfect isostasy, the difference in surface elevation. Two adjacent sections of the crust will, if of the same area, have the same mass above this depth. If the depth be assumed to be equal to the radius of the earth, it will be found that the body of the earth is not relieved of the stresses due to surface loads, *i.e.* there is no compensation. If the depth of compensation is assumed to be 100 km., the difference in densities to compensate for a difference of surface elevation of 5 km. would be 5 %. This is of the order believed to exist. Compensation may be conceived as greatest near the surface and decreasing with the depth; or it may be considered as uniformly distributed down to the depth of compensation, and as there ceasing suddenly. There are a number of such modes, each of which will satisfy the geodetic data, and geological considerations must decide the more probable. In any case the depth of compensation will depend on the distribution. Regional and local compensation may also be considered. The extreme hypothesis of local compensation is found in the assumption that each unit area, however small, is underlain by a corresponding density in its vertical column. The limit of regional compensation is reached by conceiving the whole continent as underlain by a crust of one density, an ocean basin by another density, without regarding plateaux and basins as related. The truth lies between. The best tests of the horizontal relationships between relief and density are geologic, based on a consideration of the loads which have been placed on the earth's crust without it yielding. Since enormous strains exist in the upper crust, producing, when too great, folding and faulting, it is clear that, so far as isostasy is true, the absence of strains in the zone below implies lack of strength in that zone. Rock flowage, like glacial flowage, must occur nearly as fast as the strains accumulate. The outer crust is strong enough to support individual mountains and limited mountain ranges; but it is able to flex under broader loads, so that mountain systems and broad plateaux are in greater part related to regional deficiencies in crustal densities. The strength of the crust varies in different regions and shades off into the weaker zone below. The broader and gentler flexures of this thick, strong crust involve but little crustal stress, and therefore but little deformation. But they imply a deep, slow creep in the subcrustal zone. This creep, providing the yielding zone is thick, involves but little distortion of unit mass, and is thought to be coexistent with the maintenance of a solid and rigid state. The probable mode of yielding is by recrystallisation under stress, analogous to the mechanics of the flow of ice. This combination of a strong thick crust resting on a weak but solid subcrustal shell is very different from the picture set up by the extreme isostasists of a weak and failing earth, yielding isostatically in its outer part to every minor change of load. It is also different from those hypotheses of the earth's internal nature and mode of deformation without recognition of the principles of isostasy. For regions sufficiently broad, then, the evidence is now convincing that the continental areas of the surface are underlain by masses of lower density, and oceanic areas by masses of greater density. This relation is maintained closely enough under varied conditions to lead to the further conclusion that the relationship is one of cause and effect. Over broad high areas the mean elevations are high because the subcrustal densities are low. This is quite closely true over wide areas, but less and less true as smaller areas are considered. And at some depth the strains due to unequal elevations largely disappear, and therefore the subcrustal shell is subject to little else than hydrostatic pressure. W. A. R.

200. *Contemporary Earthquakes in the Coal Measures.* **P. F. Kendall.** (Phil. Mag. 38. pp. 496–499, Oct., 1919. Paper read before the Geolog. Soc.)—Interruptions in coal-seams are known by the general name of "wash-outs." Two types are distinguished. One type is due to erosion by contemporaneous streams. Split seams are always due to this cause. After the erosion peat-producing plants grew over the channel, and the universal hog-backed shape of such wash-outs is due to the enormously contractile nature of the coal material as compared with the alluvial sediments. Other disturbances in the coal-seams, miscalled "wash-outs," the author believes to be due to earthquakes, which in Coal Measure times attained an importance hitherto unsuspected. The area in which Coal Measures accumulated resembles such alluvial tracts as were the scene of the great earthquakes of Assam and New Madrid, except that in the Coal Measures the peat beds were on a much greater scale. The formation of troughs, ridges, and fissures, the lurching out of place of belts of superficial strata, great displacements by the subterranean flow of quicksand, traces of "sandblows," and of the caving-in of river banks have all been recognised in coal-seams. Such disturbances are frequent along the margins of erosion channels, just as earthquake-formed fissures are often marked beside recent rivers in alluvial tracts. A striking abnormality in coal-seams consists in the intrusion into the coal of sedimentary material, and masses of sandstone known as "rock-rolls." These are attributed to the invasion of sands rendered mobile by water or gas, and moving under the impulse of compressional earthquake waves. All such phenomena here described were produced prior to the larger faults of the coalfield, but a few minor faults affecting a few seams only are probably to be attributed to earthquakes. W. A. R.

201. *Possible Rotational Origin of Magnetic Fields of Sun and Earth.* **J. Larmor.** (El. Rev. 85. p. 412, Sept. 26, 1919. Engineering, 108. p. 461, Oct. 3, 1919. Paper read before the British Assoc., Bournemouth,

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1919.)—The obvious solution, by convection of an electric charge, or of electric polarisation, is excluded by the enormity of the electric fields requisite in and near the body. Direct magnetisation is excluded by the high temperature. But there are other possibilities: (1) Solar surface phenomena suggest a residual internal circulation mainly in meridian planes. This would induce an electric field, and if a conducting path found the axis were open, a permanent magnetic field might build up as in a self-exciting dynamo. Again, if a sunspot be a superficial source or sink of radial flow, necessarily vertical, a strong magnetic field would result; and if it were an inflow at one level and outflow at another, the flatness and vertical restriction of the sun's magnetic field would be intelligible: (2) Electric polarisation, producing a magnetic field by rotation, might, as has been suggested, arise from gravitational or centrifugal forces. For magnetic effects to be sensible, the resulting electrified field would be too intense for any matter to sustain were it not that it would be compensated by a masking electric charge on the surface, and interiorly when the polarisation is not uniform. The enormous intensity of molecular fields suggests that such intense compensated fields are not impossible, and they would give rise to an outstanding magnetic field comparable in amount to either as the result of rotation, but not of translation along with the solar system, the effect of which would be masked by relativity. (3) An intense piezo electric field, similarly masked, might be expected in the case of a planet whose materials have crystallised out in some rough relation to the direction of gravity, or of its rotation. A magnetic field would then arise from a high speed of rotation through the ether; but relativity would mask the effects of translation without rotation at astronomical speeds. The great and rapid changes in the earth's magnetic field, comparable to its total amount, combined with the extreme stability of its material structure, as shown by the almost absolute fixity of length of the astronomical day, would seem to exclude theories of types (2) and (3). But type (1), which seems reasonable for the sun, would account for magnetic change, sudden or gradual, on the earth merely by change of internal conducting channels: though, on the other hand, it would require fluidity and residual circulation in deep-seated regions. In any case, in a celestial body residual circulation would be extremely permanent, as the large size would make effects of ordinary viscosity nearly negligible. G. W. DE T.

202. *Laws of Orbital Motion.* **A. F. Dufton.** (Observatory, 42. pp. 402–404, Nov., 1919.)—This aims at a more elaborate law than that of Bode. The author finds the times of orbital revolution of the planets to be approximately in the ratio of the cubes of simple integers. Hence, by Kepler's Third Law, the major axes of the orbits are approximately in the ratio of squares of simple integers. This law is claimed for systems of satellites as well. The paper then proceeds to find an analogy with Bohr's atom model of a nucleus with electrons revolving about it, and to consider possible periodic displacements. W. W. B.

203. *Diffraction of Images of Circular Heavenly Bodies.* **M. Hamy.** (Comptes Rendus, 169. pp. 821–825, Nov. 10, 1919.)—In continuation of previous work [see Abs. 635 and 1046 (1918)], in which the author studied the diffraction effects of an indefinitely thin slit, he now considers the case of slits of various appreciable widths, obtaining various integrals which can be fairly easily evaluated so long as a certain parameter n^2/m does not exceed 15, where n/m is the ratio of the width to the length of the slit. For higher values than 15 he proposes to find another method.

W. W. B.

204. *Time and Temperature of Formation of a Stellar Body.* **A. Véronnet.** (Comptes Rendus, 169. pp. 844–846, Nov. 10, 1919.)—Considering accretion by successive spherical layers, and having regard to Stefan's law, the author suggests "bracketing" hypotheses as to rapidity of formation, and concludes that whatever the real law of formation the mean temperature of the body remains sensibly equal to the original surface temperature, and the time of formation is of the same order after the first tenth of the nucleus has been condensed. For the sun he considers all the energy to be practically that of concentration. Then, as before [see Abs. 545 (1919)], he takes the alternatives of uniform temperature and of uniform density. If the internal temperature is assumed higher the time of formation is shortened. He concludes that the primitive sun could not have had a temperature more than three times that of its present surface, nor a radius more than double its present radius. Even then it would not have required a million years for formation, nor would its physical condition ever have been very different. If its original temperature were 6 million degrees C., the solar nebula must have contracted in 7 hours.

W. W. B.

205. *Magnitudes in Star Clusters. X. Type B and the "Local" System.* **H. Shapley.** (Nat. Acad. Sci., Proc. 5. pp. 434–440, Oct., 1919.)—The author is now discarding the hypothesis [see Abs. 1239 (1918)] that the greater part of the sidereal system is included in the "local" cluster, a flattened system of limited extent, with its plane inclined about 12° to that of the galaxy and surrounding the sun asymmetrically. He now considers this local cluster to be a very minor part of the galactic system.

The position of the sun on one side of the galactic plane makes the stars within 200 parsecs diverge about 17° from the galactic equator in Orion and Taurus, and very much less in Scorpio and Ophiuchus.

Charts are given of the distribution of the B stars: (1) those brighter than 6th mag., (2) brighter than 7th mag., and (3) fainter than 7th mag., the figures being taken from the Harvard annals. The conclusion is drawn that the brighter B stars are connected with the local cluster or secondary galaxy. Evidence is adduced that stars of all types are involved in the local cluster. The fainter B stars appear to be beyond this domain, and to belong to the main galactic system.

The sub-classes are partially indicated in the diagrams, and, on the assumption that the B0, B1 and B2 stars are intrinsically brighter than the B3 and B5 stars, the author deduces that the greater distance indicated for the first-named group, if of equal apparent brightness, justifies the inference that the local cluster is not large enough to include B1 stars fainter than 7th magnitude.

W. W. B.

206. *Spectral Lines of a Pulsating Star.* **H. Shapley** and **S. B. Nicholson.** (Nat. Acad. Sci., Proc. 5. pp. 417–423, Oct., 1919.)—If Cepheid variation is orbital, the line-shifts will be those of the body as a whole; if, on the other hand, they are due to pulsation, the effect will

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vary over the stellar disc, being maximum at the centre and zero at the limb, where all the pulsation is at right angles to line of sight. Hence, in the latter case, instead of a shift there should be a broadening of the lines towards the violet in the expanding phase, and towards the red in the contracting phase. Besides being broadened, the lines would be unsymmetrical, though this may be difficult to identify.

Cepheid variables are much darkened at the limb, and this must be taken into consideration. If for an average Cepheid the period of rotation is less than two months, the widening of the lines due to rotation will be decidedly greater than that due to pulsation. The limitation of the resolving power of any spectrograph introduces a similar masking effect due to lack of ideal sharpness of the lines. Making allowances for these various disturbing agents, the authors attempt to test the validity of the two hypotheses. The lines of δ Cephei are much wider at minimum than maximum. The change in line width observed by Adams and by Young appears to have twice the period and thrice the amplitude of that which would be produced by the distribution over the disc of a pulsating star, hence the latter, even if in itself measurable, would be masked by the larger variation due to other causes. The expected asymmetry of the lines would not show in the spectrogram.

The authors consider, and finally conclude, that no method used so far is certainly capable of determining the effects due to the pulsation hypothesis. W. W. B.

207. *Orbit of the Spectroscopic Binary* 1 *Geminorum.* **R. K. Young.** (Roy. Astron. Soc. Canada, J. 13. pp. 403–407, Nov., 1919.)—This star ($\alpha = 5h.\ 58 \cdot 0m.$, $\delta = +23° 16'$, Vis. Mag. = 4·30, type G5) was announced a spectroscopic binary in Lick Bulletin, vol. 4. Results of 51 observations (1918–19) with the 72-in. reflector at Victoria are tabulated, together with earlier results at Lick, Bonn, and Ottawa; the final elements obtained are: $U = 9 \cdot 590$ days; $e = 0 \cdot 2065$; $K = 11 \cdot 74$; $\gamma = 19 \cdot 71$ km.; $T =$ J.D. 2421898·741; $a \sin i = 1{,}510{,}000$ km. The author concludes that the star is a G type binary with the shortest period yet found, but discrepancies in the earlier observations render advisable further investigations when higher dispersion is available. H. F. H.

208. *Orbit of the Spectroscopic Binary Boss* 4669. **R. K. Young.** (Roy. Astron. Soc. Canada, J. 13. pp. 408–410, Nov., 1919.)—Results of 27 spectrograms on this star ($\alpha = 18h.\ 02 \cdot 1m.$; $\delta = 29° 46'$; Vis. Mag. 5·71; type A2), and earlier observations are tabulated. The spectrum is particularly well suited for accurate measurement, and the final elements obtained are:

$$U = 9 \cdot 6120 \text{ days};\quad e = 0 \cdot 4684;\quad K = 28 \cdot 49 \text{ km.};\quad \gamma = 7 \cdot 54 \text{ km.};$$
$$T = \text{J.D. } 2422048 \cdot 711;\quad a \sin i = 3{,}330{,}000 \text{ km.}$$

H. F. H.

209. *Colour-Changes of certain Short-period Variables.* **F. C. Jordan.** (Astrophys. J. 50. pp. 174–205, Oct., 1919.)—Long-period variables are all red, and become redder when fainter, hence the colour-change must be due to the star itself and not to the simple faintness. The eye, however, is a bad standard for colour, introducing personality. Therefore the photographic method is employed, and by the use of special plates with colour-screens the scaling of colour can be reduced to a mechanical measurement of discs, free from physiological variation.

It is shown in the present paper that a properly sensitised photographic plate used with a suitable colour-filter does actually give magnitudes of stars of all colours on a visual scale, and hence the expressions "photo-visual magnitudes" and "photo-visual light curve" can be properly applied to such results. The magnitude formula, $m = a - b\sqrt{D}$, represents within the limits of error the results with the reflector and the three kinds of plates used, also the slope of the magnitude curve (b in the formula) is practically independent of the exposure. The value of b is determined by two independent methods from Pleiades photographs, one with known magnitudes from extra-focal images and the other by means of a grating of known magnitude-absorption. For Seed 27 plates, $b = 0 \cdot 90$, and for Trichromatic and Pan-Iso plates $b = 0 \cdot 77$. The selected fields have been arranged as nearly as possible symmetrically about the centre of the plate, and always in the same position on the plate, the magnitudes being reduced to a central star of the first type as basis. In each case the photographic range is greater than the photo-visual, just as in the case of the long-period variables, indicating some change in the spectrum. The colour-index is expressed in magnitudes and is claimed to be free from any personality. W. W. B.

210. *Detailed Structure of our Stellar Universe, deduced from Dual "Whirlpool" Cosmogony.* **E. Belot.** (Comptes Rendus, 169. pp. 904–906, Nov. 17, 1919.)—Following out the general suggestion made in a previous paper [see Abs. 1368 (1919)] the author goes into details of the arrangements of the stellar universe as a two-branched spiral, similar to the well-known nebula in Canes Venatici, accounting for the directions of the various divisions of the Milky Way, and the irregular concentration in places where, according to his hypothesis, more than one branch of the spiral may be seen in the same direction. On the same hypothesis he accounts for the irregular distribution of the globular clusters, 37 of Messier's 48 being concentrated in one region. Kapteyn's two star-streams are similarly explained on the principle of perspective. He pushes the analogy with the solar system, comparing globular clusters with planets, the large ones being more distant and the concentration being on one side of the Milky Way, as that of the planets on one side of the ecliptic. W. W. B.

211. *Nebular Lines in R Aquarii.* **P. W. Merrill.** (Observatory, 42. p. 412, Nov., 1919.)—Bright nebular lines at $\lambda\lambda$ 5007, 4959 and 4363, are announced in the long-period variable R Aquarii. This may either indicate a physical condition resembling that of a nova, in which H may be replaced or accompanied by Nb, or it may be a link between planetary nebulæ and M-type stars not hitherto found. It is suggested that the recent maximum on November 22 should have provided important developments. W. W. B.

212. *Auroral Spectrum.* **T. W. Backhouse.** (Astrophys. J. 50. pp. 231–232, Oct., 1919.)—The author is surprised at Slipher's result [see Abs. 1165 (1919)] for the principal auroral line, since he himself has never had a satisfactory observation with so great a wave-length. He admits the superiority of the photographic method over his eye-observations. He is also sceptical about the presence of the principal auroral line at all times, without any definite aurora, though he has seen some of the brightest lines on rare occasions without seeing the aurora. W. W. B.

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213. *Positive-Ray Spectrograph.* **F. W. Aston.** (Phil. Mag. 38. pp. 707–714, Dec., 1919.)—The author describes improved methods of positive-ray analysis of gases based on the original method due to J. J. Thomson. The possibilities of focusing positive rays have been carefully examined with the object of increasing the intensity and sharpness of the spectral lines. The very great accuracy attained in the spectrometry of light depends largely on the fact that a considerable solid angle of divergent rays from a point source can be brought to a point image by means of a lens. Electric and magnetic analogues of the cylindrical lens are now considered in relation to the focusing of a divergent beam of positive rays. Various analogues of the cylindrical lens are described, and one of these types is applied to a positive-ray spectrograph. In this spectrograph a focused spectrum is obtained which depends solely on the ratio of mass to charge of the positive rays under examination. Actual photographic results obtained with a preliminary apparatus are submitted, showing the great accuracy possible by the method, with the aid of which the author hopes to compare masses to one-tenth of one per cent. A. B. W.

214. *New Microphotometer.* **C. Fabry** and **H. Buisson.** (J. de Physique, 9. pp. 37–46, Feb., 1919.)—Light from a source such as a mercury lamp passes first through an opening in a screen, and then through a lens which renders the beam parallel. One part of the parallel beam is reflected successively by two right-angled prisms and then passes through a converging lens to a special absorbing wedge, after which another lens renders it parallel before it traverses a Lummer-Brodhun cube, and finally the light passes through an opening in another screen. The other part of the primary parallel beam passes through a converging lens, is reflected by a right-angled prism, and then passes through the photographic plate (or other plate) under test, is rendered parallel again by a lens, and finally is reflected by the Lummer-Brodhun cube so that it passes through the same opening in the second screen. The absorbing wedge consists of a wedge of absorbing glass mounted with a transparent wedge of the same angle to give a plate of uniform thickness. The density of such an arrangement used with monochromatic light will vary according to a definite law, which will be exactly linear if the transparent wedge and absorbing wedge are of the same kind of glass. The opening in the second screen is made small, so that a uniform illumination is secured, and the absorbing wedge is adjusted to give equal brightness of the two images seen. For comparison of intensities, as for example in the case of spectrum lines, two adjustments of the wedge for two spectrum lines on a photographic plate will give the intensity ratio at once from the known variation of density of the absorbing wedge. A diagram and a photograph of the apparatus are given, with various details. Measurements can be made on either a circular or rectangular surface of less than 0·01 mm.^{2}, but by increasing the size of the opening in front of the eye to 3 mm. diam., measurements can be made on a circular area of 0·6 mm. diam. With slight additions measurements can be made on circles 3 mm. in diam. A. W.

215. *Transparency of Biotite to Infra-red Radiations.* **L. C. Martin.** (Roy. Soc., Proc. 96. pp. 185–200, Oct. 9, 1919.)—A few results for biotite have been obtained by Koenigsberger, but these are not sufficient to give the true form of the transmission curve. The work here described was designed to give as nearly as possible the variation of transmission in the most interesting points on the curve, especially near 3 μ, where so many substances (especially those containing oxygen with hydrogen) show either indications of or else actual absorption bands. The singular temperature effect observed was entirely an accidental discovery. Four specimens of biotite were tested exactly, two thicknesses from each of two varieties of biotite from differing localities. The results for each specimen are tabulated and graphed. In general, it was found that the effect of rising temperature is greatly to increase the absorption of the biotite, the transmission being halved at about + 200° C. Although there are minor variations, the effect is of the same order throughout the range of wave-lengths studied, 1·0 μ to 4·5 μ. The temperature effect is reversible, and no evidence has been found of any lagging. The absorption band near 2·9 μ becomes much weaker with rising temperature, and the form of the curve between 3 μ and 4 μ alters considerably. The curves appear to suggest that fresh absorption bands might be developed by a further increase of temperature beyond 250° C. A. W.

216. *Errors of Measurement with Range-finders.* II. **H. Schulz.** (Zeits. Instrumentenk. 39. pp. 242–252, Aug., 1919.)—A continuation of previous work [Abs. 878 (1919)]. The present paper discusses the best form of object for obtaining the least possible error. Among other things it is shown conclusively that considerably greater accuracy is obtained when the edge or edges of the object are at right angles to the line separating the portions of the field. The accuracy obtainable decreases considerably as the angle decreases from 90°. A. W.

217. *Terrestrial Refraction.* **A. R. McLeod.** (Phil. Mag. 38. pp. 546–568, Nov., 1919.)—This is a report to the Advisory Committee for Aeronautics, dealing with atmospheric refraction for various wave-lengths at different zenith distances with special reference to the errors in the Chauvenet dip-range formula. The purpose of the investigation is to obtain accurate observations of altitude of aeroplanes, balloons, shell-bursts, etc., from the ground, and of objects on the ground from the air, but it has wider applications to surveying and ultimately to astronomy.

It is usually assumed that all rays are arcs of the same circle, but the author criticises this assumption and by numerical computation accounts for the observed variability of the radius. He prefers an empirical law giving refractions for various zenith distances and for heights up to 8 km. with smaller errors than those given by the circular assumption. Better formulæ are found to replace the Chauvenet range formula for particular heights. A comparison is given between densities up to 15 km. by the empirical law and those actually observed. The surveyor's formula for refraction is criticised and errors are pointed out. The Chauvenet range formula appears to be valid except for rays which pass close to the horizon, with an accuracy of 1 in 400 for dips

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not exceeding 5°, and 1 in 100 for dips not exceeding 10°. The effect of a change of 2 % in the density is shown to be small.

Incidentally exception is taken to some statements in Winkelmann's *Handbuch*. W. W. B.

218. *Variations of Refractive Index*. **F. Twyman.** (Nature, 104, p. 315, Nov. 20, 1919.)—Experiments conducted in the research laboratory of the firm of A. Hilger, Ltd., by G. M. Fleming show that, in certain circumstances, distinct differences of refractive index may occur in certain liquids at the separating surface between the liquid and a polished glass surface. In a few exceptional cases the differences are very great; in the case of ether, for instance, they may amount to as much as 0·02 in the refractive index. As a first hypothesis, it is proposed to assume that the effect is due to variations of pressure in the neighbourhood of the interface, such variations of pressure being due to cohesion, and occurring according to the intimacy of contact between the liquid and the glass. A. W.

219. *Simple Demonstration of Huyghens' Principle*. **H. Mache.** (Phys. Zeits. 20, pp. 468–470, Oct. 15, 1919.)—Describes a method of illustrating the principle by applying the tip of a flame to a point at the edge or surface of a strip of celluloid about ½ mm. thick, say a photographic film from which the gelatine has been removed. E. H. B.

220. *Constitution of the Atom and Band Spectra*. **H. Deslandres.** (Comptes Rendus, 169. pp. 745–752, Nov. 3, 1919.)—A continuation of previous work [see Abs. 1044 and 1203 (1919) and Abs. 102 (1920)]. In the present paper the general formula for band spectra is discussed with reference particularly to the various band spectra associated with nitrogen, cyanogen, and carbon, and it is shown that the frequencies of the band maxima are multiples of one and the same infra-red frequency. The following table for the band spectra of carbon and its compounds illustrates this general law, which is also shown to apply to the other spectra dealt with.

Spectrum.	Frequency of Maxima.	Multiple of 1062·5.
Infra-red bands	3125	3 × 1062·5 = 3187
	4250	4 × 1062·5 = 4250
	6250	6 × 1062·5 = 6375
First group of carbon	19,355	18 × 1062·5 = 19,125
Second group	19,275	
Third group	31,905	30 × 1062·5 = 31,875
Negative group	41,380	39 × 1062·5 = 41,437
Fourth group	43,700	41 × 1062·5 = 43,562

The latter part of the paper gives possible atomic structures which would account for the observed facts. The scheme suggested by Nagaoka would give rise to results in accordance with the author's general formula. A. W.

221. *Double-Refraction and Stress in Glass.* **L. H. Adams** and **E. D. Williamson.** (Washington Acad. Sci., J. 9. pp. 609–623, Dec. 4, 1919.)—Glass, when stressed, becomes doubly refracting, and the paper describes a method for determining the relation between the amount of stress and the resulting birefringence. For all the glasses studied, except the heaviest flint, a thrust of one kg. per $cm.^2$ produces a birefringence of 2 to 3×10^{-7}; *i.e.* a path difference of 2 to 3 $\mu\mu$ per cm. thickness of glass. The results obtained show a satisfactory agreement with those of Pockels [see Abs. 2029 (1902) and 388 (1913)].

J. W. T. W.

222. *Absorption of some Diatomic Gases in the Near Infra-Red.* **E. S. Imes.** (Astrophys. J. 50. pp. 251–276, Nov., 1919.)—The object of the work here described was to obtain more extended and more accurate data with regard to the near infra-red absorption bands of certain diatomic gases than have been hitherto available. To this end the closely related HF, HCl, and HBr bands were mapped, using a large dispersion and an extremely sensitive galvanometer. Curves and tables of results are given, showing in greater detail the HCl bands at 1·76 μ and 3·46 μ, and giving for HBr, instead of the simple doublet hitherto known, a curve resolved into its quantum lines. In addition, a similar curve is presented for HF, which has not been studied before. Several peculiarities in these curves are pointed out. From the results obtained it is possible to calculate the length l and moment of inertia I of the three molecules. Assuming the masses of the atoms concentrated at their nuclei, which are at a distance l apart, the following results are obtained:

Molecule.	$I \times 10^{40}$.	$l \times 10^{8}$.	$I \times 10^{40}$ (Calc.).
HF	1·37	0·94	—
HCl	2·64	1·28	2·45
HBr	3·27	1·42	3·35

The last column is calculated from the kinetic theory, using Burmeister's values for the doublet maxima as corresponding to the most probable rotational frequency.

A. W.

223. *Spectrum of Neon.* **F. Paschen.** (Ann. d. Physik, 60. 5. pp. 405–453, Nov. 20, 1919.)—Tables are given of about 850 lines of the neon spectrum, from λ9840 to λ2550. The wave-lengths given are principally the author's measurements, but about 100 are taken from Meissner's tables [Abs. 750 (1919)]; these latter are chiefly the infra-red lines. The tables also show the intensities and oscillation frequencies, and indicate to which series the respective lines belong, the wave-lengths calculated from the various combination-series formulæ being included for comparison with the observed wave-lengths. The combination series are discussed and some interesting graphical relationships exhibited. The paper concludes with lists of lines assigned to the various series. [See Abs. 1794 (1908).]

A. W.

224. *Formula for Line Spectra.* **A. Lartigue.** (Comptes Rendus, 169. pp. 914–915, Nov. 17, 1919.)—The formulæ proposed by Balmer,

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Rydberg, Pickering, and Ritz can be put in the general form $10^8/\lambda = N_0[(1/p^2) - (1/q^2)]$ waves per cm., which gives the successive lines of each of the ordinary spectral series of hydrogen, lithium, sodium, etc. In each series p is a constant, or quasi-constant, and $(q - p)$ differs little from the series of consecutive integers or semi-integers. Putting $q - p = m$, the above formula can be expressed in the form:

$$\lambda_m = \frac{4 \times 10^8}{N_0}\left(\frac{p}{2}\right)^3\left(\frac{2}{p} + \frac{1}{m} - \frac{1}{m + 2p}\right) \text{Ångstroms.}$$

For $p = 2$ and $m = q - 2 = 1, 2, 3 \ldots .29$, this reduces to the ordinary Balmer formula for the hydrogen lines; but from the new form it appears as if the wave-lengths of a fundamental vibration $\lambda_\infty = 3646$ Å., and of two equidistant harmonics of order m and $(m + 4)$ are added algebraically. More generally, the new form allows all series to which the old formula is applicable to be decomposed into three sets of elementary terms, the first of these being constant, or quasi-constant, and the two others tending towards zero. A. W.

225. *Conditions for Maximum Fluorescence.* **L. Bruninghaus.** (Comptes Rendus, 169. pp. 531–534, Sept. 22, 1919. Le Radium, 11. pp. 262–265, July–Aug., 1919.)—The author discusses the results of some experiments begun in 1910, but interrupted, and only recently completed. He finds the amount of phosphorescence or fluorescence due to a given excitation procedure is greatest when the solution is very dilute and the exciting radiation is very feebly absorbed. G. W. DE T.

226. *Fundamental Constants of X-ray Spectrometry.* **Ledoux-Lebard and Dauvillier.** (Comptes Rendus, 169. pp. 788–791, Nov. 3, 1919.)—The values of the grating space for the crystal of $CaCO_3$ as determined by various physicists (Bragg, Webster, Compton, Uhler and Cooksey, and Siegbahn) are collected and the weighted mean determined. The value $d = 3{\cdot}0346 \times 10^{-8}$ cm. thus obtained agrees with remarkable accuracy with the value $3{\cdot}0344 \times 10^{-8}$ cm. calculated by the authors. A. W.

RADIO-ACTIVITY.

227. *Relation between "Mass per Unit Area" and "Air Equivalent" of Mica Sheets for α-rays.* **R. W. Lawson.** (Akad. Wiss. Wien, Ber. 127. 2a. pp. 943–949, 1918.)—A simple apparatus is described for the visual determination of the air-equivalent of metal foils and thin sheets of mica.

It has been found for mica (density = 2·87) that there exists a linear relation between air-equivalent and mass (in milligrammes) per cm.^{2} A mass of 1·46 mgm./cm.^{2} has an air-equivalent of exactly 1·0 cm. of air at 751 mm. and 20° C. That is, 1·50 mgm./cm.^{2} of mica is equivalent to 1·0 cm. air at 760 mm. and 15° C. Using this constant, therefore, the air-equivalent of any mica sheet can be determined by the simple operation of weighing. A. B. W.

228. *Absorption of Diverging γ-rays.* **M. Blau.** (Akad. Wiss. Wien, Ber. 127. 2a. pp. 1253–1279, 1918.)—The question is first examined mathematically, the discussion being followed by an experimental investigation of the points raised in the theory. The original should be consulted if detailed information is desired. A. B. W.

229. *Distribution of Radio-active Substances in and over the Sea.* **V. F. Hess.** (Akad. Wiss. Wien, Ber. 127. 2a. pp. 1297–1313, 1918.)—The paper commences with a general discussion of the interchange of matter due to phenomena of diffusion, heat motion, etc., and applies this to a consideration of the movements of radio-active substances in the earth, the atmosphere, and in the oceans. Separate sections of the paper deal with the questions of the radium, thorium, and uranium content of seas, oceans, ocean beds, and rivers. The question of evaporation is considered in relation to this problem.

As a result of his analysis of the question, the author concludes that an average quantity of $1\cdot04 \times 10^{-17}$ curie of emanation is given up to the atmosphere by one cm.^{2} of sea-surface per sec. An earlier determination, by W. Schmidt and the author, of the emanation escaping from the land surfaces of the globe gave a value from 2 to 3×10^{-17} curie of emanation per cm.^{2} per sec. Since about ¾ of the earth's surface is covered by water, it would appear from the above results that the total amounts of emanation escaping from the surface of the sea and the land are approximately equal. A. B. W.

230. *Negative Corpuscular Radiation of Cosmic Origin.* **E. v. Schweidler.** (Akad. Wiss. Wien, Ber. 127. 2a. pp. 515–533, 1918.)—The hypothesis that the vertical component of current in the earth's atmosphere could be maintained by the conduction of negative charges through the earth in the form of a very penetrating β-radiation, has been experimentally proved. The questions relating to the upper limits of absorption and the penetrating power of the β-radiation are discussed. A. B. W.

231. *On the Question of the Existence of Isotopes of the same Atomic Weight. The End-product of the Thorium Series.* **S. Meyer.** (Akad. Wiss. Wien, Ber. 127. 2a. pp. 1283–1296, 1918.)—It is shown that the thorium-lead separated by Soddy from thorite possesses a purely α-radiation, which is completely accounted for by the polonium derived from the small admixture of uranium (to which it is proportionate) in the thorite. The radiation ratio, as well as the results of different analyses of thorium minerals indicate the probability that the products resulting from the two branches of the Th series are both stable. The author consequently concludes that there is no basis for the assumption of the existence of isotopes of "higher order" with the same atomic weight. A. B. W.

232. *Metallic Disintegration Produced by α- and β-rays.* **R. W. Lawson.** (Akad. Wiss. Wien, Ber. 127. 2a. pp. 1315–1337, 1918.)—With the object of elucidating the phenomenon of the "apparent volatility" of radio-active substances from metal surfaces at ordinary temperatures, the author has considered the possibility that this effect is produced by α-rays in a manner similar to the kathodic disintegration produced by canal rays. It has been proved that such an effect undoubtedly exists, but the volatility hypothesis is by no means sufficient to explain the phenomenon. It is possible to obtain a reasonable explanation of

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the results by assuming the atoms of radio-active matter to be deposited on the metal surface in clusters or aggregates. These atom aggregates are thrown off the metal surface as a result of α-recoil, and thus simulate volatilisation of active matter at ordinary temperatures.

A simple method for the demonstration and measurement of the disintegration of different metals when bombarded by α-rays is described. In this method the surface of the metal foil to be examined is coated with polonium, this radio-active substance acting as an "indicator" of the atoms thrown off the metal surface when bombarded by α-particles from a very active layer of RaC below. The atoms of metal leaving the surface are collected and their activity (due to the adhering polonium) measured. Thin foils of the metals Pt, Ag, Cu, Au, Pd, Ni and Al were examined in this manner.

A similar series of experiments was made to determine the disintegration produced by β-ray bombardment, but the effect, if any, was too small for detection. A. B. W.

233. *Electrolytic and Colloidal Solutions of Radio-Elements.* **G. v. Hevesy.** (Akad. Wiss. Wien, Ber. 127. 2a. pp. 1787–1798, 1918.)—In neutral, alkaline, and weakly acid solutions it has been observed that for strongly electro-negative electrode potentials the "baser" radio-metals dissolve more rapidly in a given time than the "nobler" radio-metals. This receives an explanation on the ground that in such solutions a fraction of the radio-elements in question exists in the colloidal form. The anomalous behaviour disappears, however, when the dissolved portion of the electrode is expressed as a fraction, not of the *whole* solution, but of that portion of it in the electrolytic condition.

A simple method is described by means of which a quantitative estimation can be made of the fraction existing in the electrolytic state. In distilled water only about 7 % of ThB and 1·5 % of ThC exists in the electrolytic condition ; these fractions increase rapidly with increasing acidity of the solution, becoming, *e.g.*, in 0·001 normal acid, 45 % and 25 % respectively. A. B. W.

234. *Structure of Radio-active Elements.* **I. W. D. Hackh.** (Phil. Mag. 39. pp. 155–157, Jan., 1920. Chem. News, 120. pp. 103–104, Feb. 27, 1920.)—The author gives a table of radio-active elements, similar in character to that of Soddy, which indicates the change in position in the periodic table as a radio-active substance disintegrates by emission of α- and β-rays. From this arrangement the author derives a partial structural formula for each of the radio-active isotopes.

A B W.

HEAT.

235. *Heat Transmission.* **O. Wiener.** (Ann. d. Physik, 60. 4. pp. 324–328, Nov. 13, 1919.)—This paper formulates a general proposition relative to the effect of the interposition of thin layers of some material in hindering the transference of heat between two surfaces. A theoretical proof is given that if the amount of the heat transferred between two neighbouring surfaces is determined by the difference of two functions, each of which is a function only of the temperature and other properties of the surfaces in question and independent of the distance apart of the surfaces, then the heat transference (in the stationary condition) between the two surfaces is reduced to the *n*th part when $(n - 1)$ parallel thin layers are interposed at equal distances between the two surfaces.

A. W.

236. *The Ignition of Gases by Hot Wires.* **W. M. Thornton.** (Phil. Mag. 38. pp. 613–633, Nov., 1919.)—Previous work on hot-wire ignition is briefly reviewed in the introduction to the paper. A number of experiments on the hot-wire ignition of gases, chiefly of the paraffin series, under various conditions are described. Curves are given showing the current required for ignition with wires of different metals, *e.g.* platinum, iron, gold, tungsten, of varying diameter. The relationship between igniting current and diameter of wire is linear, excepting in the case of silver. The temperature of the wires when ignition occurs is calculated and shown to be much lower than that required when ignition is caused by external heating. The values obtained agree with those given by Bone, as the temperatures at which surface combustion commences. The effects of (*a*) varying the proportion of gas to air, (*b*) decreasing the pressure, and (*c*) increasing the pressure are exhibited by means of curves. Experiments are described in which the wire causing ignition was subjected to strong electromagnetic and electrostatic fields.

The results may be summarised briefly as follows: Ignition is independent of gas pressure, of the heat of combustion of the mixture, of the proportion of gas, and, for any given metal, independent of the nature of the combustible molecule so far as diameter is concerned; hydrogen and platinum are exceptions. The mechanism of hot-wire ignition is an attack upon oxygen either within the wire or by positive ions of combustible gas just ejected from it Electrostatic and electromagnetic fields have no influence on surface combustion so far as ignition is concerned.

N. W. M.

237. *Flame Velocity in Inflammable Gases.* **J. D. Morgan.** (Engineering, 108. pp. 535–536, Oct. 24, 1919.)—The author suggests and examines the proposition that the flame velocity and pressure during the combustion of inflammable gases are simply related in such fashion that the flame velocity is proportional to the gas pressure. Considering the simplest case, that of combustion in a long cylinder closed at both ends and provided at one end with an igniting spark gap, the author deduces, from his original proposition, the expression $p = p_0e^{At/p_0}$,

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and he finds that actually the p-t diagram agrees with this equation. He regards the suggestion that the flame velocity is proportional to the gas pressure as therefore verified. Further, it is deduced that if the composition and initial pressure of the gas mixture be kept constant, the time of reaching the final pressure and final velocity will differ with the length of the cylinder, although the final pressure and velocity will be the same for the same gas mixture. The relation between l and t is given by the expression $\log Bl = Ct$, where B and C are constants. As regards the initial part of the p-t diagram, it is a well-known fact that when a spark record is also made, the instant of ignition does not coincide with the apparent origin of the pressure. It is shown experimentally by the author that this no-pressure interval is due not to the gas, but to the indicator. If this is true, then the p-t curve will have its origin at the instant of the passage of the spark. The curve rises very slowly at first, and consequently indicators designed to resist the maximum pressure of the explosion would not be capable of indicating the initial pressure.

The author considers that his equations are also related to the law of mass action, whereby a wider basis is given to his suggestion than is found in the experiments he cites. A. F.

238. *The Energy-Content of Solids in the Light of Recent Investigation.* **E. Schrödinger.** (Phys. Zeits. 20. pp. 420–428, Sept. 15; 450–455, Oct. 1; 474–480, Oct. 15; 497–503, Nov. 1, and pp. 523–526, Nov. 15, 1919.)—In these 5 papers the author collects together into one harmonious whole a survey of recent investigations into the energy-content of solids. He commences with a comprehensive set of references to the work of Richarz, Eucken, Solvay, Wigand, Grüneisen, Nernst, Planck, and himself. (1) In the first paper a short summary of the entire ground covered is given. The classical view that every degree of freedom denotes an equal average thermal energy is shown to be untenable when the number of degrees of freedom, kT, is caused to vary by complex formation, this being shown to have the value $h\nu/(e^{h\nu/kT} - 1)$ for the frequency ν. The classical theory with respect to the laws of Dulong, Petit, and Neumann-Kopp then receives attention. Following this come the two Planck hypotheses, the relationship to the Nernst theory of heat, and the monochromatic theory of atomic heats. (2) The second paper deals with experimental methods, reference being made to the work of Dewar, Eucken, Nernst, Keesom, and Onnes. Details of apparatus and procedure are given and illustrated by diagrams. An investigation of the monochromatic theory is included for thermally simple substances. Then comes a discussion of the Nernst-Lindemann formula, the mechanical spectrum, and the approximation of Debye. This paper teems with references to the literature of the subject. (3) The third paper continues the discussion, and contains an experimental examination of the Debye theory. Then comes a review of other formulæ for special frequencies, followed by a discussion of the Debye theory. Again, very full references are included. (4) The fourth paper deals at some length with the space-lattice theory of atomic heat, the work of Born and Karman, Thirring, v. Laue, Flamm, Goldhammer, etc., being critically examined. The following important result is adduced, namely: that exact agreement of optical special frequencies with those claculated from elastic considerations or the prediction of thermo-energetic behaviour from frequencies of one or another species alone, is in general no longer to be expected with complex structures;

the agreement of the order of dimensions is a valuable proof that in the crystal, atomic forces of the same species and dimensions produce, on the one hand, the union between the chemically different atoms, and on the other, the texture of the entire crystal structure. (5) The final paper contains a review of some hitherto unsettled problems in connection with the quantum theory. This concluding section deals with the atomic heats at high temperatures, and with ferro-magnetism. Again, the references are very numerous and comprehensive, and the set of papers should prove most valuable as a bibliography of the subject. H. H. Ho.

239. *Vapour Pressures of Mercury in the Range* 120° *to* 250°. **A. W. C. Menzies.** (Am. Chem. Soc., J. 41. pp. 1783–1787, Nov., 1919.)—An arrangement is described for the measurement of low vapour pressures, in which use is made of two McLeod gauges, the one being immersed in an oil-bath and kept at a high temperature, while the other is kept at the ordinary temperature by immersion in water. The vapour pressure of mercury between the temperatures 120° and 250° is found to be in accordance with the equation: $\log p = 9{\cdot}9073436 - 3276{\cdot}638/\theta - 0{\cdot}65199041 \log \theta$, which was based on measurements carried out between 250° and 435° in 1910 [see Abs. 370 (1910)]. T. S. P.

240. *A Vapour-pressure Equation.* **G. W. Todd** and **S. P. Owen.** (Phil. Mag. 38. pp. 655–660, Nov., 1919.)—In a previous paper [Abs. 767 (1919)] the authors considered the influence of temperature on homogeneous reactions from the point of view of the kinetic theory. In the present paper they investigate the simplest type of heterogeneous reaction —the equilibrium of a vapour in contact with its liquid—making the assumptions (1) that all vapour molecules striking the liquid surface penetrate it, and (2) that only those liquid molecules which have a velocity greater than a definite critical value, whatever their angles of impact with the surface, penetrate it and get clear. On these assumptions the authors deduce the vapour-pressure equation $p = \mathrm{A}\rho\epsilon^{-\mathrm{B}/\theta}(1 + \mathrm{B}/\theta)$, where $\mathrm{B} = mc_1^2/2\mathrm{R}$. In the few cases where density data up to the critical temperature are available, this expression agrees well with the experimental results over the whole range of temperature through which the liquid phase exists. For moderate ranges of temperature, where it may be assumed that the concentration of the liquid molecules remains constant, the expression $p = \mathrm{A}'\epsilon^{-\mathrm{B}/\theta}(1 + \mathrm{B}/\theta)$ is sufficiently good. The authors have calculated the value of B from the critical temperature of the liquid, and have compared it with the value obtained from the vapour-pressure equation. It is found that the two values are not identical, but the former is generally about one-third to one-quarter of the latter. A. F.

241. *Isothermals of Monatomic Substances and their Binary Mixtures.* XX. *Isothermals of Neon from* + 20° to − 217° C. **C. A. Crommelin, J. P. Martinez,** and **H. K. Onnes.** (K. Akad. Amsterdam, Proc. 22. No. 2. pp. 108–118, 1919. Comm. No. 154a. from the Phys. Lab., Leiden.) —Further progress has now been made in the reduction of the neon isothermals, the measurements embracing pressures up to about 90 atmos. and temperatures between + 20° and − 217° C. The whole of the data referring to neon is given in the form of tables, which show the values of the normal density d_{A} and normal volume v_{A} corresponding with different magnitudes of the temperature (θ) on the international Celsius scale, and of the pressure (p) in international atmospheres. By means of these results some of the coefficients in the empirical equation of state, $pv_A = A_A + B_A d_A + C_A d_A^2 + D_A d_A^4 + E_A d_A^6 + F_A d_A^8$, have been computed; values are given for B_A, C_A, D_A, and E_A, the densities reached being insufficiently high to allow of the calculation of F_A, and in most cases also of E_A. The correspondence between the new values and those previously derived is, on the whole, satisfactory. T. H. P.

242. *Integration of the Helmholtz Thermodynamic Differential Equation according to the Nernst Theory of Heat.* **A. Byk.** (Phys. Zeits. 20. pp. 505–512, Nov. 15, 1919.)—The Nernst theory of heat may be so formulated that the Helmholtz differential equation, $A - U = T dA/dT$, which includes the two principal laws of thermodynamics, may be integrated under the condition that $dA/dT^{(T=0)} = 0$, where A is the maximum work of the respective process, U the thermal condition, and T the absolute temperature. The general integral is $A = -T\int U/T^2 dT + a_0 T$, where a_0 is the arbitrary constant of the differential equation of the first order. If U be expanded as a temperature function at constant pressure in the form of a power series with an indefinite but finite number of terms, viz. $U = U_0 + \alpha T + \beta T^2 + x_1 T^3 + x_2 T^4 + \ldots$, then A is obtained in the form of an indefinite integral, $A = -T\int^T U/T^2 . dT$. The lack of a lower limit is due to a defect in statement, and Nernst met the difficulty by putting $A = U_0 - \Sigma\nu F$, where $F = T\int^T E/T^2 . dT$, and $E = \int_0^T C_p . dT$. The author now investigates a solution for the lower limit of the integral without separation of U_0. The paper is mathematical throughout. H. H. Ho.

243. *Gay-Lussac and Boyle Temperatures.* **R. H. Weber.** (Ann. d. Physik, 60. 3. pp. 291–296, Oct. 20, 1919.)—Schames has defined three characteristic curves for real gases [see Abs. 319 (1919)], which are bound up with the three component laws of ideal gases, and to these he has given the names Boyle, Gay-Lussac, and Joule curves respectively. The three laws, viz. Boyle, $(\partial(pv)/\partial p)_T = 0$; Gay-Lussac, $T(\partial v/\partial T)_p - v = 0$; and Joule, $T(\partial p/\partial T)_v - p = 0$, are not independent of each other, but connected together by the general relationship between three variables: $(\partial v/\partial T)_p = -(\partial v/\partial p)_T . (\partial p/\partial T)_v$, corresponding to the fact that only two properties are characteristic of ideal gases, namely, that the product (pv) is solely a temperature function (which is arbitrary and dependent on the choice of temperature scale), as likewise the internal energy, which latter, however, is not arbitrary. The last equation shows that when two of the characteristic curves cut, then the third curve must also pass through this point. Considerations, however, are now advanced to show that such a case can only happen at $T = 0$, when certain facts have general validity. It is shown that the Jäger-Boltzmann expression for the equation of state, $pv + a/v = RT(1 + b/v + a_1 b^2/v^2 + \ldots)$, is valid between the Boyle point (where $p = 0$ on the Boyle curve) and the inversion point. H. H. Ho.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS AND ATMOSPHERIC ELECTRICITY.

244. *Radiation from Moving Magneton.* **H. Bateman.** (Nat. Acad. Sci., Proc. 5. pp. 367–371, Sept., 1919.)—The author points out that the radiation of a single electric pole describing a circular orbit is certainly positive as indicated by the formulæ of Larmor and Liénard. Schott, moreover, has calculated the radiation from a ring of electrons describing a circular orbit, and from various other distributions of moving electric charges and magnetic poles, and finds that the radiation of energy is almost invariably positive [Abs. 1216 (1918)]. Electromagnetic theory in its present form, therefore, lends no support to Bohr's idea of non-radiating orbits. A steady distribution, such as a Parson magneton, which consists of a complete ring of electric charges following one another round the ring at a constant speed, will evidently give no radiation when the ring, as a whole, is stationary, but, as Schott remarks, may be expected to radiate energy when its centre is accelerated. Schott's results are so important that confirmation by an independent method is desirable, and the author has sought for one by which the rate of radiation from a moving electric pole and magnetic doublet may be readily calculated.

Starting with the case of an *electromagnetic doublet, i.e.* an electric doublet and magnetic doublet moving together, E and H are determined from the appropriate equations, as also for an electromagnetic pole and for a combination of electromagnetic pole and electromagnetic doublet. The rate of radiation across a very large sphere whose centre is at the moving point is then calculated. For a magneton of constant charge and moment describing a circular orbit, so that the axis of the magneton remains perpendicular to the orbital plane, the radiation is positive: for given velocity and acceleration of the system, the rate of radiation is about 1/8 of that from the electric charge alone. Referring to a suggestion by Swann to the author of the desirability of calculating the radiation from an electron rotating on its axis like a planet, while describing a circular orbit, if such an electron can be treated to a first approximation, as a magneton, the foregoing result is applicable. The fact that the radiation is reduced by rotation may indicate that revolving electrons do rotate. A similar calculation for the case in which the axis of the magneton is tangential to the path indicates that the rate of radiation is greater than that from the electric charge alone. The calculations show that when an electromagnetic pole and an electromagnetic doublet move together with constant velocity along a rectilinear path, it is possible for the moment of the doublet to change at a constant rate without there being any radiation of energy. G. W. DE T.

245. *Nature of Electricity.* **R. Fürth.** (Deutsch. Phys. Gesell., Verh. 21. pp. 517–528, Aug. 30, 1919.)—The author starts with the four logical possibilities: (1) Both positive and negative electricity continuous and infinitely divisible; (2) both consisting of irreducible quanta; (3) negative continuous, positive in quanta; (4) positive continuous, negative in quanta. A detailed discussion of the experimental evidence leads to the conclusion that it is all in accordance with either (2) or (4). But the results of Ehrenhaft's experiments on the charges of microscopic and ultramicroscopic particles negative (2), leaving only (4) as in agreement with all available experimental evidence. If this be the case, positive charges can exist only in connection with matter, which agrees with the experimental evidence. Such a constitution would account for the observed existence, especially in gases, of ions carrying charges of every possible amount, and would account more naturally than (2) for the canal-ray phenomena and for the charges of the water particles in a mist. The author suggests that it appears quite within the limits of possibility that the "electrons" may be exceptionally stable groupings of electric charges, analogous to the quanta in which energy, although essentially continuous, is observed under certain conditions. G. W. DE T.

246. *Size and Shape of the Electron.* **A. H. Compton.** (Phys. Rev. 14. pp. 247–259, Sept., 1919.)—J. J. Thomson has pointed out that a formula in accordance with the experimental variation of fluorescent absorption with the wave-length of the incident rays and with the atomic number of the absorber may be obtained by the assumption of an incident X-ray pulse of special form. The author shows that this hypothesis, combined with Moseley's law relating to atomic number and the wave-length of characteristic X-radiation, leads to E. A. Owen's experimental law [Abs. 1162 (1918)] for the fluorescent absorption of moderately soft X-rays. But it is shown that this formula would not apply if, as argued in the author's previous paper [Abs. 1533 (1919)], the wave-length becomes comparable with the radius of the electron. The author therefore modifies this formula (1) by assuming, in accordance with his previous paper, a decreased scattering when the wave-length becomes comparable with the diameter of the electron, and by assuming the electron to have the form of a flexible ring. He then obtains satisfactory agreement with the experimental values for the absorption of high-frequency radiation by aluminium, the only substance for which the requisite data are available for an adequate test, provided the diameter of the ring be taken as $(1{\cdot}85 \pm 0{\cdot}05)10^{-10}$ cm., a result in good agreement with his previous estimate of 2×10^{-10} cm. on the basis of measurements of scattering of high-frequency radiation. G. W. DE T.

247. *Report on Electromagnetic Induction.* **S. J. Barnett.** (Am. I. E. E., Proc. 38. pp. 1151–1169, Oct., 1919.)—After a brief enumeration of fundamental results from the time of Faraday, self-induction is considered as identical with inertia, and references are given to experiments on the inertia of free ions and on electric displacement in conductors due to their acceleration. Motional e.m.f. and motional intensity as affected by the relation of ether and matter, with the resulting displacement in insulators, are dealt with, and references to the recent experiments demonstrating its existence are given. The induced e.m.f. in fixed conductors and insulators arising from changes in other systems is considered both in terms of magnetic flux and of the vector potential expressing the phenomena directly as due to motion of electrons. The relations between induced and motional e.m.f.'s and the resulting electric displacements, and the phenomena of unipolar induction, are considered in some detail, more particularly in

connection with experiments which have been made with the object of obtaining evidence for or against the existence of a fixed ether.
G. W. DE T.

248. *A New Type of Electric Wind.* **V. F. Hess.** (Archives des Sciences, 1. pp. 547–548 Nov,. 1919. Paper read before the Soc. Suisse de Physique.)—It is well known that when an electric wind is produced by points, ions of the same kind generate, at some distance from the point, a current of air which has a definite direction. In the same way ionisation produced by radio-active substances may give rise to quite considerable currents in the ionised air. This phenomenon which has been observed by Zeleny for X-rays, and by Ratner for β-rays, may perhaps better be referred to as "wind of ionisation," since the displacement of the air is due to entrainment of the ions in motion. The author has measured the pressure of this wind of ionisation by a torsion balance arrangement, similar in some respects to that employed by Ratner in his experiments. A study has been made of the variation of the wind pressure with different field intensities and ionisation densities. Dust in the air is the cause of considerable discrepancies observed in the results. The speed of the air-particles entrained by the ions is found to be approximately 1/10th the speed of the ions themselves. A. B. W.

DISCHARGE AND OSCILLATIONS.

249. *Photo-Electricity of Gels.* **H. Zwaardemaker** and **F. Hogewind.** (K. Akad. Amsterdam, Proc. 21. 9. pp. 1146–1151, 1919.)—In the course of an investigation of aromatic substances the authors found that the three following conditions govern the existence of photo-electricity in liquids: (*a*) The dissolved substance must be photo-electric; (*b*) the solution must largely absorb ultra-violet light; (*c*) the solution must be colloidal. Among the photoelectric colloids they found activity in horse's blood, hen's albumen in glycerine, saturated aqueous solution of nuclein, agar, and gelatine solutions, vulcanised rubber, and silicic acid discs covered with some of the above. E. E. F.

250. *A Photoelectric Anomaly of Paraffin.* **F. Luchsinger.** (Archives des Sciences, 1. pp. 544–546, Nov., 1919. Paper read before the Soc. Suisse de Physique.)—The author examines the density of some small spherical particles of paraffin, obtained by pulverisation of the melted substance, and concludes it is that of the substance in mass.

It is found that, illuminating the particles between the plates of a condenser by ultra-violet light, they are not attracted to the negative plate like metallic particles, but are displaced towards the positive plate. This can only be explained by a loss of positive electricity from the particles, control experiments showing that the effect is not caused by emission of electrons from the plates of the condenser, nor by ionisation of the air. The conditions necessary for the phenomenon are discussed. The effect is a property of the particles, the charges on which vary by multiples of a quantity which is calculated to be that of the elementary electrical charge, assuming the density of the particles to be that of the mass of the substance. The explanation of the mechanism of the separation of positive electricity from the particles, analogous to the emission of electrons in the normal photoelectric effect, is left for further research. T. H.

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251. *Ionisation Potential of Helium.* **J. Franck** and **P. Knipping.** (Phys. Zeits. 20. pp. 481–488, Nov. 1, 1919.)—After a brief discussion of the results obtained by various workers for the ionisation potential of helium, details are given of new measurements. Measurements of the resonance potential gave the mean value 20·5 ± 0·25 volts. From this the ionisation potential may be calculated, giving the result 25·3 ± 0·25 volts. Direct measurements of the ionisation potential gave the value 25·4 ± 0·25 volts, the resonance potential again being 20·5 volts. Further experiments showed that at 79·5 ± 0·3 volts the electron collisions resulted in the production of ionic pairs from the impurities in the apparatus. From theory previously advanced [Abs. 752 (1919)], taking the ionisation potential of hydrogen atoms to be 13·52 volts, and consequently that of the helium atomion to be 54·08 volts, the subtraction of the latter value from 79·5 volts gives again the value 25·4 volts. Using a similar method, Horton and Miss Davies [Abs. 781 (1919)] obtained results in close agreement with the present determinations [see Abs. 1043 (1919)]. A. W.

252. *Thermionic Emission.* **F. Wolfers.** (J. de Physique, 9. pp. 95–114, March, 1919.)—The theories of Richardson and of Langmuir are considered in some detail, and it is concluded that the intensity of the current may be limited in two distinct manners: (1) It is limited for a given temperature by the emissivity capacity of the filament; when the p.d. is sufficient a saturation current i_0 is obtained, which is given by the well-known Richardson formula, $i_0 = a\sqrt{(\mathrm{T})}e^{-b/\mathrm{T}}$. (2) For a given p.d. the intensity is limited by the accumulation of electrons in the space which possesses only a certain definite power of conduction; if the temperature of the filament is sufficient a saturation current i_s is obtained, which can be calculated by Langmuir's law, $i_s = \mathrm{AV}^{3/2}$, in which A is a constant depending only on the conformation of the system, and V is the applied voltage. The effect of the residual gas is also considered under the following subheads: (1) Increase of conductivity; (2) δ-rays. If the p.d. is very great the positive ions bombard the kathode with sufficient energy to provoke a complimentary emission of electrons; (3) disintegration of the filament; (4) inert gases; (5) rectifiers with argon; (6) a general study of the gases. It is concluded that the gas present has a considerable influence upon thermionic emission. On account of the fact that the pressure and state of ionisation of the residual gas vary in a most irregular manner, the electronic emission, properly so-called, may be entirely masked. The irregularities in a curve which shows the intensity as a function of the p.d. only disappear when an ultra-rarified gas (one in which the molecular free-path is large compared with the dimensions of the apparatus) is employed. A. E. G.

253. *Luminous Phenomena near a Plate of Graphite at a High Temperature.* **G. A. Hemsalech.** (Comptes Rendus, 169. pp. 915–918, Nov. 17, 1919.)—A plate of Acheson graphite, 0·95 mm. thick, 10 mm. broad, and 37 mm. long, was mounted in a horizontal position between two rods of graphite 12 mm. in diam., which were connected to a battery able to give for several seconds a current up to 300 amps. The upper surface of the plate was covered with a thin layer of powdered carborundum, and the whole arrangement was set up in air at atmospheric pressure. The temperature of the lower surface of the plate could be raised to a temperature of about 3300° C. with a current of 260 amps. and a fall of potential of 8 volts/cm. The space below the plate is protected by the lower surface of the plate, and limited at the sides by convection currents, and it is in this space that the phenomena in question are produced; they are observed readily by projecting an enlarged image of the incandescent plate on a white screen. At temperatures from 2300° to 2500° C. a steady state is reached, a "bluish vapour" being constantly given off, the lower edge of the vapour being sharply defined and the appearance above the plate being stable. The spectrum of this vapour is continuous. Within the protected space a much more intense light is given out by the vapours, but the spectrum of this light is composed of lines and bands. The vapour within the protected space is called the "luminous vapour," and the "bluish vapour" appears to be due simply to the cooling of the luminous vapour at the borders of the protected space. The luminous vapour is ionised very considerably. If the temperature is raised to 3000° C., a reddish band, 1 to 2 mm. thick, appears immediately below the surface of the plate, and the lower boundary of this band is quite sharp. This is called the "red fringe," and its spectrum, though altogether different from that of the luminous vapour, is also composed of lines and bands. The fringe is probably due to a current of thermo-electrons, which give rise to emission centres different from those of the luminous vapour. The application of a magnetic field, besides affecting the red fringe, gives rise to a system of strongly luminous helices and spirals, due to ionic trajectories. In certain cases cycloidal and trochoidal curves have been observed on the screen, due to the projection of these trajectories in the direction of the lines of magnetic force. A. W.

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254. *Determination of Rate of De-ionisation of Electric Arc Vapour.* **H. G. Cordes.** (Inst. Radio Eng., Proc. 7. pp. 527–539, Oct., 1919.) —After discussing the de-ionisation and consequent loss of conductivity of mercury vapour carrying a momentary arc, the author considers an arrangement of circuits for determining the rate of de-ionisation, and the effect of this rate on the voltage required for a subsequent re-ignition. The theory of the circuits is developed, and illustrated by numerical examples. Experimental evidence is required to test the theoretical conclusions, as these may have important practical applications.

A. W.

255. *Influence of the Magnetic Field on the Discharge through Nitrogen, and a Diamagnetic Effect.* **W. Steubing.** (Phys. Zeits. 20. pp. 512–519, Nov. 15, 1919.)—Describes spectrographic observations on the positive column of a direct-current discharge through pure N and the effect of longitudinal and transverse magnetic fields. With pressures varying from 0·1 mm. to 1·5 mm., and current of the order 1 milliampere, the two band spectra, red-yellow and blue-violet are of equal intensity. With increase of current the intensity of the former increases more rapidly than that of the latter. The width of the discharge tube was of the order 11 mm. The negative band spectrum is present, but only weakly developed. With application of a transverse magnetic field the column is deflected and the line of current is bluish-white in the field, while outside the reddish-yellow light wholly persists. The brightness of the second band spectrum is increased considerably, current being adjusted to same value. A similar behaviour is observed in a longitudinal field. Here the tube passed through holes in the pole-pieces of an electromagnet. The portion in the air-gap was expanded into a symmetrical spheroidal form. On excitation of the field a further phenomenon is observed. A bluish glow of disc-like form appears in the centre of the expanded portion perpendicular to the lines of force and the current. The spectrum of this is identical with that of the negative glow. L. L.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

256. *The Electric and Magnetic Fields.* **A. Mandl.** (Elektrot. u. Maschinenbau, 37. pp. 485–488, Oct. 26, 1919.)—A discussion of Maxwell's equations bearing on the electric and magnetic energies per unit of volume. These are expressed respectively as $4\cdot42\epsilon' E_v^2 10^{-14}$ Joule/cm.^{3} and $3\cdot98\ \beta^2/10^9\mu'$ Joule/cm.^{3}, where ϵ' is the dielectric constant of the insulator as compared with that of a vacuum, E_v is the field intensity in volts per cm., β is the magnetic induction, and μ' is the permeability. Taking mica and iron as examples, it is calculated that 22·6 kg. of mica can store 1 Joule, the weight of iron required to store the same amount of energy being 2·62 kg. These numbers indicate why it is practically difficult in a power station to do away with energy vibrations in magnetic alternating fields by the substitution of condensers. G. E. A.

257. *Dielectric Constants of Gases.* **H. Riegger.** (Ann. d. Physik, 59. 8. pp. 753–760, Sept. 19, 1919.)—This paper deals with the dependence of the dielectric constants of gases on temperature. The measurements were made with the help of a Mandelstam dynamometer. The gases used were air, hydrogen, methane, CO_2 and CO, and the temperatures ranged down to − 191° C. The results are presented in tabular form. In the case of air, hydrogen, methane and CO_2, the results are in close agreement with the dipole theory. The agreement for CO is not so good. [See Abs. 1601 (1914) and 625 (1919).] A. W.

258. *Thermoelectric Effects in Chemically Homogeneous Circuits produced by Mechanical Treatment.* **G. Borelius.** (Ann. d. Physik, 60. 4. pp. 381–404, Nov. 13, 1919.)—Thermo-couples were formed of various metals and drawn or rolled samples of the same material. The magnitude of the thermoelectric effect obtained depends on the ratio of the periphery to the sectional area of the portion mechanically treated. For a metal crystallising regularly the effect is isotropic. It increases until the ratio attains a certain critical value; a surface effect then appears. The thermoelectric effects described by Benedicks when a homogeneous circuit is asymmetrically heated have their origin, in the opinion of the author, in the strain and surface effects which he describes. L. L.

259. *Electrical Conduction by Free Electrons and Carriers.* III. **P. Lenard,** with contributions by **W. Weick** and **H. F. Mayer.** (Ann. d. Physik, 60. 4. pp. 329–380, Nov. 13, 1919.)—The objective of the present communication was laid down by the author in a publication so far back as 1900, in which a general formula for the velocity of electrical carriers in gases was worked out. There remained the consideration of special complex cases, as well as the more detailed treatment of molecular motion, and the connection of the Stokes-Kirchhoff resistance law for larger bodies.

Parts I and II of this series of investigations were published in 1913, and the present Part III now brings the problem to a definite conclusion.

First, the factors are obtained explicitly, whereby simple velocity formulæ are derived according to the masses of the wandering particles, in order that the molecular motion of the medium and of the particles may be exhaustively treated, including the inequalities of the velocities and free-paths. Secondly, the different possibilities are investigated of the behaviour of the medium molecule at the surface of the wandering particle in its influence upon the velocity, so that, in addition to the usually accepted case of elastic reflection at smooth spherical surfaces, other extremely different limiting cases are considered. Thirdly, the transition is investigated from these results, which have been obtained exclusively from the kinetic theory of gases, to the Stokes-Kirchhoff resistance law which has been derived exclusively from hydrodynamical considerations. An important application lies in the possibility of investigating the as yet unknown sizes of submicroscopic and other bodies difficult to measure, from observed velocities under known forces. In this way the magnitudes of electrical carriers may be obtained, and also the transformations of their states. Application is next made to the case of electrolytic ions, and then to the problem of electrical quanta. The author claims that all the general results of the kinetic gas theory and of hydrodynamics are adequately considered in his formulæ, so that a fundamental basis free from objection has been obtained in the treatment of any special cases.

The paper comprises 10 sections, of which 5 are published in the present paper, namely: I. Gas kinetic inequalities in the velocity formula (Distribution of velocity and free-path); II. Influence of the motion of the medium molecule on the loss of velocity of a particle by impact; III. Criticism of the degree of approximation attained; IV. The impact periods of molecules in gas mixtures; V. Different aspects of the behaviour of the medium molecules at the surface of the particle. Here 5 cases are considered, viz. Elastic impact between completely spherical particles; Diffuse reflection—when the particle is built up of a sufficiently large number of molecules its surface may be either of a molecular or coarser structure; Reception of the medium molecule at the particle surface and the subsequent emission for rotating and thermal transmitting particles; Perpendicular evaporation of the molecule at a non-rotating particle; Distance forces between particle and medium molecules. The next 5 sections are promised for an early date. The whole paper is full of references to previous work on the subject. H. H. Ho.

260. *Small Poulsen Arc for Experimental Purposes.* **M. Gildemeister.** (Elekt. Zeits. 40. pp. 616–617, Nov. 27, 1919.)—This paper describes the construction of a small arc which has been found useful and convenient. The arc chamber is formed by a cylindrical glass tube about 6 cm. diam. and 5 cm. long. The upper end of the tube is cemented into a metal ring, which itself fits inside another metal ring, the two rings being screwed together; a rubber ring is fitted between the lower edge of the outer and a projecting flange on the inner ring to make the joint air-tight. The outer ring has a flat metal top, underneath which is soldered a metal tube 4·5 cm. in diam. and 2·5 cm. long. The lower end of the tube is provided with a small flange, to which is soldered a disc of copper 0·4 mm. thick, which serves as one electrode. The small chamber thus formed is provided with inlet (central) and outlet tubes for water cooling. The lower end of the glass tube projects about 1 cm. below the surface of mineral oil contained in a vessel provided with a central tube, through which passes a metal rod carrying at its upper end a short piece of carbon rod about 3 cm. in diam. A set screw is used to adjust the arc-length, and a spring attachment is fitted so that momentary contact can be effected between the carbon and copper electrodes. Inlet and outlet tubes to the arc chamber pass through the base of the oil container, their ends being about 1 cm. above the surface of the oil. Hydrogen is used for filling the arc chamber, and only a small rate of flow is necessary. The arc is operated on 220 to 250 volts through iron resistances in hydrogen, and works well with a current of 2 amps. For frequencies from 1000 to 25,000 the best results are obtained with the ratio of the self-induction to the capacity in the oscillatory circuit (self-induction in henrys and capacity in mfd.) about 4 : 1. The p.d. across the arc while oscillations are taking place varies from 90 to 120 volts. A. W.

261. *Mechanical Model to Illustrate Alternating-Current Phenomena.* **J. Bruncken.** (Köln. Techn. Blätter, No. 1. 1918. Elekt. Zeits. 40. pp. 555–556, Oct. 30, 1919.)—After discussing mechanical analogues of self-induction, e.m.f., etc., a description is given of a model to illustrate transformer action. A bar A is pivoted at the centre, and carries equal masses (adjustable in position) at its ends. At equal distances *a* from the centre are attached the connecting rods of two pistons working in vertical cylinders provided with adjustable outlets near the base. Directly above the bar A is another bar B, also pivoted at the centre, the distance between the centres being fixed, since both pivots pass through the same standard. B is slightly longer than A, and carries larger masses. Two other connecting rods are attached to B at equal distances $b (< a)$ from the centre, and the corresponding cylinders are attached to A, the pivots for such attachments also being at equal distances *b* from the centre of A. These cylinders are also provided with adjustable outlets near the base. The system is such that oscillations are possible with both beams in a vertical plane, and if the oscillations of A correspond to the current in a transformer primary, those of B will represent the secondary current. The size of outlet from the cylinders corresponds to " damping " in the electrical case ; the moment of inertia of the beams and attached masses, to self-induction, and the ratio a/b corresponds to the ratio n_2/n_1 of the windings of the transformer secondary and primary. A. W.

262. *Ionisation Gauge.* **S. Dushman** and **C. G. Found.** (Frank. Inst., J. 188. p. 819, Dec., 1919. Abstract of G.E. Co.'s Laboratory Notes.)—The design of " ionisation " gauge used by the authors consists of two concentric tungsten filaments inside a coaxially situated cylinder. The inner filament is used as a source of electrons with the outer one as anode, while the cylinder is used as positive-ion collector. The gauge was calibrated by the " flow " method for extremely low pressure.

Calibration of the gauge with different gases led to the interesting relation that the number of positive ions formed at constant electron emission and constant pressure is proportional to the number of electrons per molecule of the gas ionised. It is possible, therefore, by this method to determine the " molar numbers " for different gases. By " molar number" is meant the sum of the products, Atomic number times Number of atoms, taken for each atom in the molecule. Thus the molar number of iodine is $2 \times 53 = 106$, and for HgI_2 it is $80 + 2 \times 53 = 186$.

The mean free path of the molecules in argon is found to be 150 cm. at 1 bar pressure, and the diameter of the electron is calculated on this basis to be about $4 \cdot 4 \times 10^{-9}$ cm. A. B. W.

ALTERNATING CURRENTS AND MAGNETISM.

263. *Magnetic Effects of Vibration in Iron Rod.* **A. O. Rankine** and **F. B. Young.** (Phil. Mag. 38. pp. 528–532, Nov., 1919.)—The rod was a cylindrical one of mild steel, 6 ft. long and 1 inch in diam., clamped at its centre. A short brass lever fixed at one end at right angles to the rod could be struck by a lead bar so as to throw the rod into torsional, longitudinal, or lateral vibration. Observations were made by means of a small search coil connected to a three-valve amplifier and telephone. The ends of the rod were connected by a conductor of low resistance to form a closed circuit of considerable area. Tests were made with the search coil in three typical positions with respect to this circuit; namely, coil in same plane as conductor, axis of coil parallel to conductor, and axis of coil at right angles to and passing through the conductor. The indications observed showed that complex magnetic changes were caused in the iron bar by its own vibrations, and no very simple or definite relation exists between the mode of vibration and the structure of the resulting magnetic field. Longitudinal vibration, however, seems to be associated with marked oscillation in longitudinal magnetisation. The second and third overtones were the most prominent tones obtained from the bar. G. E. A.

264. *Researches on Solenoids composed of Magnetic Material.* **L. Lombardi.** (Accad. Lincei, Mem. 11. pp. 814–867, 1916.)—This memoir forms a continuation of the author's work on the distribution of current in iron conductors [see Abs. 661 B (1915)]. *Theoretical.*—The first part contains a review of previous work on the theory of the resistance and inductance of coiled conductors, and the author's conclusions as to the practical applicability of the theories discussed are as follows:—(1) The original Wien theory cannot be accepted, even for non-magnetic materials, without reservations, since it is based on the conception, unrealisable in practice, that the current is uniformly distributed; still less is it applicable for material of high permeability. (2) Sommerfeld's first theory and that of Coffin are rigorous and applicable to magnetic solenoids, but they deal with a case that is not found in practice; the results can be obtained from Rayleigh's theory of plane laminæ. (3) Neither Batelli's theory nor Picciati's can be used for the quantitative determination of the resistance or inductance. (4) Sommerfeld's second theory involves the use of very complicated functions. (5) Cohen's theory also presupposes a distribution of the turns and field not exactly realisable in practice, and it lacks experimental confirmation. Nicholson's theory is certainly applicable in the case of magnetic materials, but cannot be applied to solenoids having turns some distance apart. (7) Esau's theory is subject to the same reservations as Wien's. (8) Lenz's formula cannot be used, except in cases where the permeability is unity and the frequency low. (9) Möller's theory accounts well for the phenomena

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in solenoids with subdivided non-magnetic conductors, and can be used for calculation of the effective resistance at any frequency; it is not applicable, however, to material of high permeability. (10) Edward's theory of the current distribution in rectangular conductors is also only valid for non-magnetic material. (11) Rogowski's theory is of importance and may be used in alternator and transformer design. (12) The investigations of Kennelly, Laws, and Pierce have confirmed Kelvin's theory for solid conductors. (13) Jouaust's results, in so far as they contradict the Thomson theory for magnetic thin sheets cannot be accepted without reservations.

Experimental.—The second part deals with the measurements carried out on two solenoids of iron wire and having the dimensions and characteristics as given below :—

	Magnet A.	Magnet B.
Number of turns	2 × 14	2 × 20
Length, cm.	120	88
Distance between turns	4·05	2·08
Sect. area of conductor, cm.^{2} ..	3·80	0·61
Mean diam. of turn............	28·08	24·0
D.C. resistance, ohm............	0·0090	0·075
Max. permeability	1890	1160
Hysteretic coefficient	0·00233	0·00320

For these coils the author first calculates the values of the external inductance and the relative magnetic parameters, using Kelvin's theory for a straight conductor and certain corrections as set forth fully in the memoir. He then compares these values with those obtained from experiment, the values being given for three frequencies (50, 100, 150) and for three strengths of current (100, 150, 200 amps.). The ratio of the calculated to the observed values of the resistance and equivalent inductance are given, together with the electrical dimensions, in two tables. For solenoid B there is a mean negative divergence of 2 %, and this divergence does not at any time exceed 4 %. For solenoid A, of larger-section wire, the divergence is more marked and is positive; it increases both with the frequency and the current strength: the ratio ranges from 1·04 to 1·22 in the case of the resistance, and from 1·22 to 1·64 in the case of the inductance. Some experiments were also made with subdivided conductors made up of a bundle of 580 iron wires of 0·4 mm. diameter and of resistance approximately that of solenoid A. It was found that at 50, 100, and 150 cycles the effective resistance was 0·0123, 0·0151, and 0·0177 ohm, *or* 15, 41, and 65 % greater than the minimum d.c. resistance (0·0112 ohm); the power factor had the values 0·93, 0·88, and 0·85 respectively.

The original should be referred to for the large amount of information contained therein. L. H. W.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

265. *Constitution of the Elements.* **F. W. Aston.** (Nature, 104. p. 393, Dec. 18, 1919.)—A number of substances have been analysed in the positive-ray spectrograph, and some remarkable results have been obtained. Up to the present oxygen, methane, CO, CO_2, neon, HCl, and phosgene have been admitted to the bulb, in which, in addition, there are usually present other hydrocarbons (from wax, etc.) and mercury. Of the elements involved hydrogen has yet to be investigated. Carbon and oxygen appear, to use the term suggested by Paneth, perfectly "pure"; neon, chlorine, and mercury are unquestionably "mixed." Neon consists of isotopic elements of atomic weights 20 and 22. The mass-spectra obtained when chlorine is present appear to prove conclusively that this element consists of at least two isotopes of atomic weights 35 and 37. Their elemental nature is confirmed by lines corresponding to double charges at 17·50 and 18·50, and further supported by lines corresponding to two compounds HCl at 36 and 38, and in the case of phosgene to two compounds, COCl at 63 and 65. In each of these pairs the line corresponding to the smaller mass has three or four times the greater intensity. Mercury, the parabola of which was used as a standard of mass in the earlier experiments, now proves to be a mixture of at least three or four isotopes grouped in the region corresponding to 200. Several, if not all, of these are capable of carrying three, four, five, or even more charges. Accurate values of their atomic weights cannot yet be given. A fact of great theoretical interest appears to underlie these results, namely, that of more than forty different values of atomic and molecular mass so far measured, all, without a single exception, fall on whole numbers, carbon and oxygen being taken as 12 and 16 exactly, and due allowance being made for multiple charges. Should this integer relation prove general, it should do much to elucidate the ultimate structure of matter. On the other hand, it seems likely to make a satisfactory distinction between the different atomic and molecular particles which give rise to the same line on a mass-spectrum, a matter of considerable difficulty. [See Nature, p. 334, Nov. 27, 1919.] A. W.

266. *Constitution and Structure of Chemical Elements.* **H. Collins.** (Chem. News, 119. pp. 295–296, Dec. 26, 1919.)—"It is well known that electro-positive charges emanate from masses of 1 (hydrogen), 7 (lithium), 23 (sodium), and 39 (potassium); also that two electropositive charges emanate from 4 (helium), of which one has been shown to emanate from a mass 3; therefore it is evident that single charges emanate from each of the following masses: 1, 3, 7, 23, 39." With this statement as a basis, the author proceeds to demonstrate, by means of a table, how the atomic weights of all the elements can be divided up in a uniform manner, making use of the "fundamental masses." Thus C, $12 = 7 + 1 + 3 + 1$; Al, $27 = 23 + 1 + 3$; Ti, $48 = 39 + 1 + 3 + 1 + 3 + 1$, etc. It is shown that the element is split up into as many parts (1, 3, 7, 23, and 39) as the element has valencies. References are made to other interesting deductions, but for information relating to these the original paper should be consulted. A. B. W.

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267. *The Hydrides of Bismuth and Polonium.* **F. Paneth.** (Akad. Wiss. Wien, Ber. 127. 2a. pp. 1729–1761, 1918.)—Using a novel method of indication, the author demonstrates conclusively the production of the gaseous hydrides of bismuth and polonium in certain chemical reactions. He makes use for this purpose of the isotopic character of bismuth with the radio-active substances ThC or RaC. An alloy of bismuth and magnesium is treated with dilute acid containing one of these "indicators." The gaseous product evolved is pumped off into an "emanation" electroscope, and is found to exhibit radio-active properties corresponding to RaC or ThC, as the case may be. From these and chemical considerations the author shows that the gaseous product can be none other than bismuth hydride BiH_3.

Using a similar method, the production of the gaseous hydride of polonium is also demonstrated. A. B. W.

268. *Minimum Thickness of Layers of Metal, as measured by their Electromotive Force.* **S. Procopiu.** (Comptes Rendus, 169. pp. 1030–1031, Dec. 1, 1919.)—Using a zinc anode and platinum kathode, zinc is deposited on the latter from a solution of zinc sulphate; the thickness of the deposit can be calculated from Faraday's laws and the area of the kathode. When the current is broken the deposited zinc begins to dissolve, a back e.m.f. being set up. The curve showing the relation between this back e.m.f. and the time is continuous for a certain period, and then shows a sudden break. Different thicknesses of zinc are deposited, and the rate of solution investigated as described. A curve is then drawn showing the relation between the thickness of the deposit and the time necessary for the break to appear; this curve is a straight line, and the point where it cuts the axis of thickness of deposit is taken as giving the minimum thickness of the layer of metal which is capable of exerting an e.m.f. This minimum thickness is found to vary with the metal on which the zinc is deposited, and is as follows for various kathodes: Al, 0·3 $\mu\mu$; Pt, 0·8 $\mu\mu$; Fe, 1·6 $\mu\mu$; Ag, 2·8 $\mu\mu$; Cu, 4·2 $\mu\mu$; Ni, 4·8 $\mu\mu$. Corresponding with these different thicknesses the inclinations of the straight lines to the axis of thickness vary with the metal on which the zinc is deposited, and this is considered to be due to diffusion (alloying) of the zinc into the kathode. The thickness of the first layer of zinc molecules deposited is probably less than the value 0·3 $\mu\mu$ obtained with an aluminium kathode. The minimum thicknesses of layers of copper deposited on Pt, Ag, and Cu respectively are 0·25 $\mu\mu$, 0·8 $\mu\mu$, and 1·2 $\mu\mu$. The ratio of the thicknesses of the deposits on Ag and Pt are approximately the same (3) for zinc and copper, as also is the case for the deposits on Cu and Pt, the ratio then being 5. T. S. P.

269. *Thermal Relations in the Treatment of Steel.* **C. F. Brush.** (Am. Inst. Mining Eng., Bull. No. 153. pp. 2389–2407, Sept., 1919.)—Bars of tool steel containing 1·14 % C commenced immediately after quenching to generate heat, which reached a maximum 8 hours afterwards and was still perceptible 4 weeks later. The total evolution corresponds to a rise in temperature of 5 deg. C. In the case of a Cr-W high-speed steel hardened from a white-heat, the heat generation is the same in character as in the carbon steel, but much less in amount and somewhat more persistent. A spontaneous contraction recurs in the hardened steel amounting to about 0·05 %; the time rate of change of this yields

a curve closely similar to that given by the heat generation. There seems little room for doubt that the two phenomena are intimately connected. The spontaneous shrinkage is, however, only incident to, and not the prime cause of, the generation of heat, since the work represented by the latter is very much greater than that required to produce the observed compression. In certain cases also heat generation has been observed without shrinkage. It is considered that the spontaneous relief of a small portion of the strain present in the hardened steel is the cause of the thermal effect. In the case of nickel-chrome steels quenched just *below* the carbon change-point, an exactly similar heat generation occurred, about ¾ of the amount of heat evolved from the fully hardened sample being given out. Surface oxidation of the steels does not result in measurable heat generation. Nickel-chrome steels quenched at temperatures from about 650° to 560° C. show a distinct absorption of heat, cooling more rapidly than the annealed material. In the case of carbon steels, heat evolution ceases at once when the quenching temperature falls short of the A1 point. Manganese steel (C, 1·18 %; Mn, 12·29 %) showed no heat generation after water-quenching at any temperature between 1013° and 615° C. **F. C. T.**

270. *Researches on the Fluidity of Metals and Alloys.* **D. Saito** and **K. Hayashi.** (Kyoto Coll. Eng., Mem. 2. pp. 83–100, July, 1919.)—In determining the fluidity of the metals the molten material was cast into a spiral mould; the section of the casting was 10 mm × 7 mm., the max. possible length 5000 mm. The casting is made in a dry sand mould from a central feeder. The greater the fluidity of the metal the greater will be the length filled. The casting is done under a definite head of metal in a crucible, the perforated bottom of which can be closed by a plug. The test-pieces weighed up to 6 kg. The principal results obtained are given below.

Material.	Casting Temperature, ° C.	Degree of Overheating, ° C.	Fluidity (*i.e.* Length of Test-piece in mm.).
Lead	410	83	3007
Zinc	480	61	2970
Tin	250	18	3074
Antimony	650	20	1877
Aluminium	680	23	900
Copper	1150	66	1720
Bronze, 19·4 Sn 1·2 Zn	1145	245	2400
Bronze, 10·3 ,, 1·8 ,,	1180	180	1600
Bronze, 11·4 ,, 1·8 ,,	1145	165	1745
Bronze, 8·6 ,, 5·0 ,, 0·6 P	1100	200	1743
Brass, 34·4 Zn	1090	140	1637
Brass, 44·5 ,,	1020	120	1957
Redcar grey pig-iron	1320	140	3250
White pig-iron	1255	155	433
Steel, ·42 C ·46 Si ·67 Mn	1600	200	1140

The low fluidities of aluminium and white pig-iron are noteworthy. The temperature of the mould was about 40° C. **F. C. T.**

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271. *Experimental Investigation of the Influence of Rate of Cooling on the Hardening of Carbon Steels.* **A. M. Portevin** and **M. Garvin.** (Iron and Steel Inst., J. 99. pp. 469–559; Corres., 560–563, 1919.)—The formation of troostite on cooling a carbon steel corresponds with a rapid transformation at a temperature of about 650° C.; that of martensite, with a relatively slow one at 300° or under. The former point, Ar′, is well marked, while the production of martensite is marked simply by a change in the gradient of the curve. In the case of the same steel and the same initial temperature of cooling, the point Ar′ is gradually lowered as the velocity of cooling is increased. At a certain critical rate the point moves from Ar′ to Ar″. Accompanying this change a corresponding variation is produced in the microstructure, and the hardness of the quenched product. Where both points Ar′ and Ar″ are found the structure consists of both martensite and troostite. The critical rate of cooling, *i.e.* the minimum for the complete hardening, is a minimum for the eutectoid composition, and is lowered as the manganese present in the steel is increased. The influence of the size of the test-piece on the quenching is investigated with the following results: For constant conditions of steel and cooling the quenched structure is martensite, and the Brinell figure is high up to a diameter of about 13 mm. Above this size the hardness suddenly drops to a constant lower figure, and troostite makes its appearance at the centre. The experimental arrangement used is described in detail, while in 4 appendices are considered: (*a*) the influence of the internal evolution of heat on the duration of cooling; (*b*) the temperature of the starting of hardening cracks (from 70° C. downwards); (*c*) some experiments on the quenching of special steels; and (*d*) the influence of pressure on the formation of troostite.

F. C. T.

272. *Heat of Hydration of Gaseous Atomic Ions.* **K. Fajans.** (Deutsch. Phys. Gesell., Verh. 21. pp. 549–558, Aug. 30, 1919.)—The considerations of Abs. 162 (1920) indicate that it should be possible to distinguish the two components of the heat of solution of a salt: the heat required for the complete dissociation of a salt into its free ions, and the heat of solution of the ions in water. The latter component, hydration of the ions, must be additive for kation and anion. If $(\overset{+}{\text{K}}) + (\overset{-}{\text{Cl}}) = [\overset{|}{\text{K}}\text{Cl}] + \text{U}$, and $[\text{KCl}] + \text{Aq} = \overset{+}{\text{K}}\text{Aq} + \overset{-}{\text{Cl}}\text{Aq} + \text{L}$, then by addition: $(\overset{+}{\text{K}}) + (\overset{-}{\text{Cl}}) + \text{Aq} = \overset{+}{\text{K}}\text{Aq} + \overset{-}{\text{Cl}}\text{Aq} + \text{U} + \text{L}$. At ordinary temperature the A will differ but little from U_{300}: hence the values of A previously found may be used, and $\text{W}_{\text{kat+an.}} = \text{A} + \text{L}$. If further $(\overset{+}{\text{Na}}) + (\overset{-}{\text{Cl}}) + \text{Aq} = \overset{+}{\text{Na}}\,.\,\text{Aq} + \overset{-}{\text{Cl}}\,.\,\text{Aq} + \text{W}_{\text{Na+Cl}}$, and similarly $(\overset{+}{\text{K}}) + (\overset{-}{\text{Cl}}) + \text{Aq} = \overset{+}{\text{K}}\,.\,\text{Aq} + \overset{-}{\text{Cl}}\,.\,\text{Aq} + \text{W}_{\text{K+Cl}}$, then by subtraction $\{\overset{+}{\text{Na}}, \text{Aq}\} - \{\overset{+}{\text{K}}\,.\,\text{Aq}\} = \text{W}_{\text{Na+Cl}} - \text{W}_{\text{K+Cl}} = \text{W}_{\text{Na}} - \text{W}_{\text{K}}$, since also $\overset{+}{\text{K}} + \text{Aq} = \overset{+}{\text{K}}\text{Aq} + \text{W}_{\text{K}}$. Thus the difference between the heats of hydration of the Na-ions and the K-ions is found. In this way the author deduces the difference between any pairs of the ions Li, Na, K, Rb, Cs, Tl, Ca, and proves the additivity of ionic hydration heats. Passing to the heat of hydration of single ions, the author starts from the heat balance of the transition of an element into the state of a dissolved ion after Helmholtz-Gibbs and Ostwald, and he finds the value + 362 cals.

for the union of a hydrogen nucleus with much water to form the hydrogen ion of an aqueous acid solution. Similarly he obtains for the heat of hydration, W, of other ions: Li, + 210; Na, + 203; K, + 182; Rb, + 173; Cs, + 174; Tl, + 182; $\overset{++}{\text{Ca}}$, + 475; and Cl, − 23; Br, − 32; I, − 43, all in kg.-cals. per gm.-atom. The probable errors amount for the kations to 6 %, for the anions to 10 %; if the n were not 9 (as assumed), but 7, *e.g.*, the tabulated figures would only be changed by 2 or 3 %. Attention is drawn to the far-reaching consequences of these considerations, with special regard to the electrostatic nature of valency-forces after Kossel. H. B.

273. *Some Chemically-Reactive Alloys.* **E. A. Ashcroft.** (Faraday Soc., Trans. 14. pp. 271–275; Disc., 275–277, July, 1919.)—The alloys consist of magnesium (5 to 50 %) and lead (or cognate metals). The alloy with 15 % Mg rapidly oxidises in the cold or in moist air, falling into a black powder, a mixture of the hydrates; the oxidation is merely due to the atmospheric oxygen, the water effecting hydration; on further exposure to moist air the powder turns brown or pink. This reaction might serve for absorbing oxygen and for preparing nitrogen in the cold. The alloy with 35 % Mg generates hydrogen when boiled with water, but the action is confined to the magnesium, unless the temperature is raised to 150° in sealed vessels. The hydrate mixture can be utilised, sometimes without separating the two hydrates, for the preparation of lead peroxide (by chlorine) or white lead. The alloys themselves are prepared by fusing the metals together, or more conveniently by electrolysing the anhydrous magnesium chloride of the author [Brit. Pats. 12,873 and 13,259 of 1916] in closed cast-steel cells, with an overflow weir, a kathode of fused lead and anodes of graphite or amorphous carbon; the chlorine escapes. The alloys are kept in sealed cases. Alloys of cognate metals (CaZn, etc.) are mostly less reactive; but the Mg-Zn hardly oxidises at all in the air, and is yet a very active substitute for Mg in pyrotechnics.—In the *discussion,* **C. H. Desch** mentioned that the peculiarity of Mg_2Pb (19 % Mg) had been described by Grube in 1905. It was stated that the alloys are ineffective in the absence of moisture; further applications were suggested. H. B.

274. *The Molecular Theory of Solution.* **S. C. Bradford.** (Phil. Mag. 38. pp. 696–705, Dec., 1919.)—A discussion of the views of Traube on cohesive pressure and of J. J. Thomson and Sutherland on the electrical theory of atomic structure with references to the recent researches of Holmes and Sageman and of Bingham, from the general standpoint that solution must be of the nature of vaporisation. H. B.

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